# POWER PLANT ENGINEERING

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# An Australian Electric Railway Power Plant

WHEN COMPLETED, WILL HAVE CAPACITY OF 60,000 KW. AND SUPPLY POWER TO 335 MI. OF ELECTRIFIED STEAM RAILWAY

IN THE YEAR 1913 plans were made and work commenced on the electrification of the comprehensive suburban lines of the government-owned Victorian Railway, in and around Melbourne, Australia. The war necessarily delayed the work somewhat, and the first train was not run until May 29, 1919. At present about 200 mi. of track are in electrical operation.

The whole scheme of electrification, which was described in the Commonwealth Engineer (Melbourne, Australia), possesses features of exceptional interest. This is particularly true of the power plant, which serves not only as an example of modern practice, but as an illustration of the trend of foreign power plant development.

The main buildings of the plant are of steel frame construction, with walls of cement plaster and hair, reinforced with expanded metal, carried on steel lathing, supported by the building columns.

The turbine room measures 300 by 76 ft., the height to the crane runway being 62 ft., and to the highest point of the roof 98 ft. Adjoining the turbine room is the pump house, 275 by 31 ft. in size. The two boiler rooms, each 170 by 77 ft., extend at right angles from the pump house. The height from the grate surface to the top of the six steel tracks provided on each boiler room is 84 ft.

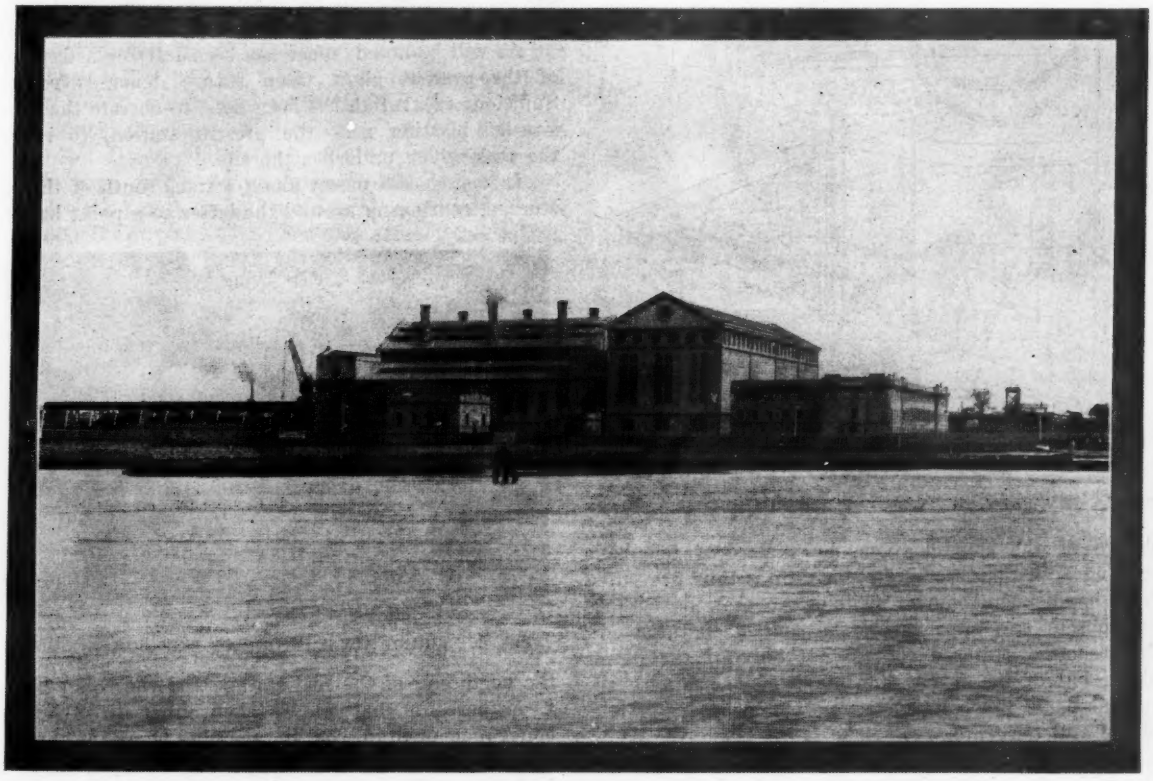


FIG. 1. THE NEWPORT POWER STATION

Between the boiler houses are located the storeroom, laboratory, tank house, and various offices, and on the river side, the machine shop. North of the turbine room is a brick building containing step-up transformers, unit transformers, neutral earthing resistances, battery rooms, motor-generator rooms with auxiliary switch and fuse distribution boards, and air filtering plant. Another brick building, 299 by 44 ft. in size, further to the north, contains the switching equipment, with the control room at the west end and the administration offices at the east end.

An interesting feature of the control system is that the only means of communication between the switch house and turbine rooms is through the operator in

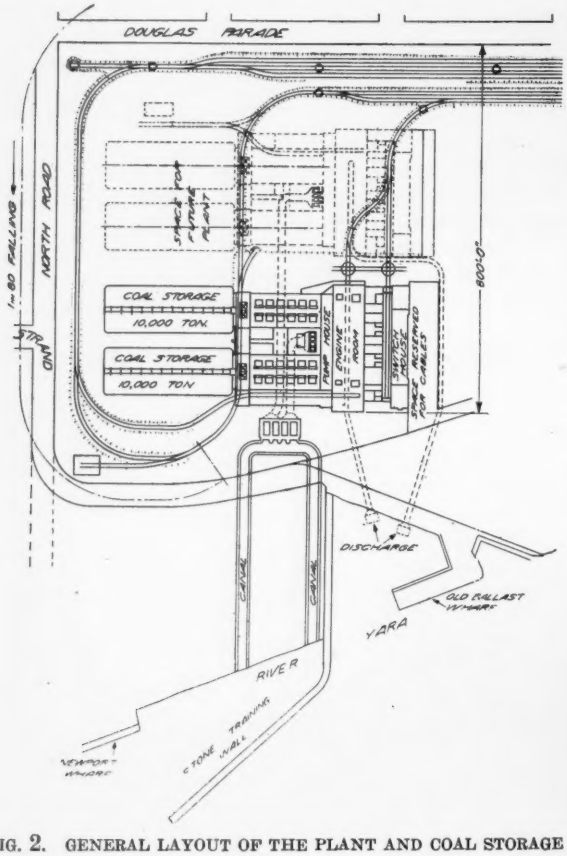



FIG. 2. GENERAL LAYOUT OF THE PLANT AND COAL STORAGE

charge of the control room, by means of telephone or telegraph. The turbine room staff is thus prevented from having control over switching operations without the consent and approval of the control operator. In this room is centered control not only of the power plant, but of the whole transmission system, with the various parts of which it is connected by means of telephone and telegraph.

At a short distance from the main buildings, and alongside the circulating water canals, is the screen house, containing the screens and pumping plant in connection therewith.

The circulating water entering the intake canals from the river passes through grids of steel bars, placed 3¾ in. apart, to prevent fairly large flotsam passing further on, then through 6-ft. penstocks, which, when closed, permit cleaning of the screening pits. The water then passes through the traveling screens, Fig. 6, which remove any further foreign matter which would be likely to clog the condenser tubes, and discharge it into a mud box. Two electrically-driven centrifugal pumps supply water at 50 to 60 lb. pressure for continuous washing of the screens. When the circulating water plans were made, advantage was taken of the existing stone training wall shown in the plan, Fig. 2, to prevent the discharge water from mingling with and warming the intake water. The discharge passes into the bay to the north of the wall and is guided thereby towards the middle of the river and past the inlet canals.

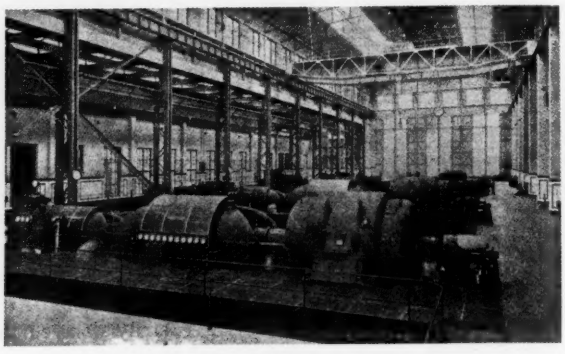


FIG. 3. THE TURBINE ROOM

As will be noted, space has been left for a duplicate of the present plant when future demands require. Sufficient excavation has been done to obviate the necessity of blasting near the present station, to remove the rock which underlies the site.

Incoming coal passes along a track south of the coal storage, continuing around the latter to a point between

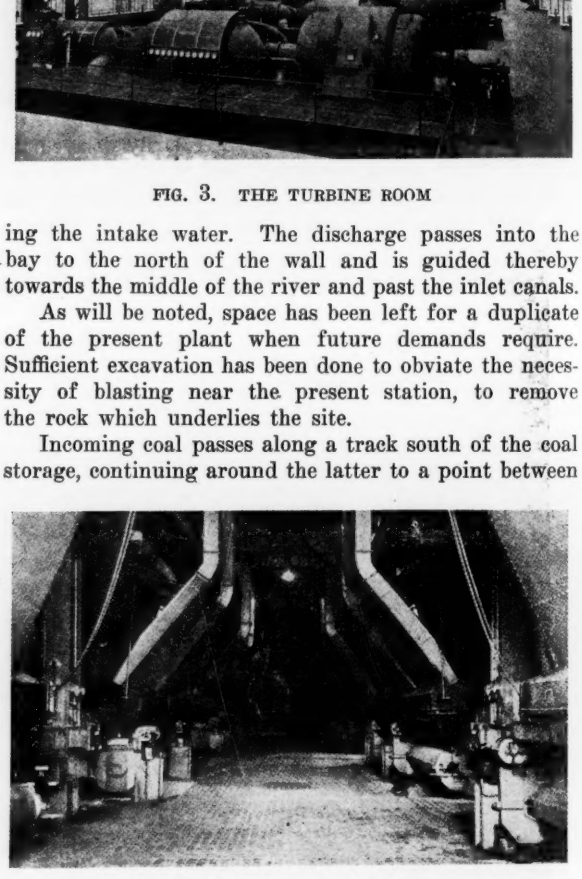


FIG. 4. FIRING AISLE IN ONE OF THE BOILER HOUSES

the north end of the coal storage and the boiler houses. From here the coal can be taken either directly to the boiler room or to the coal storage piles by means of traveling bucket conveyors. Gantry cranes are provided over both coal storage piles, each carrying a 4½-ton electric jib crane, for handling coal from storage to crusher hoppers.

## Boiler Room Equipment

THE STEAM-PRODUCING equipment is equally divided between the two boiler rooms, each containing 12 marine-

type, water-tube boilers, Fig. 7, with a heating surface of 6725 sq. ft. per boiler. Each boiler is provided with 168 sq. ft. of grate surface in the form of electrically-driven, two-section chain grate stokers. Economizers with a heating surface of 2880 sq. ft. and return-tube superheaters with 1043 sq. ft. of heating surface are provided for each boiler.

The boilers are arranged in pairs, each boiler with its own economizer and superheater, but the exhaust

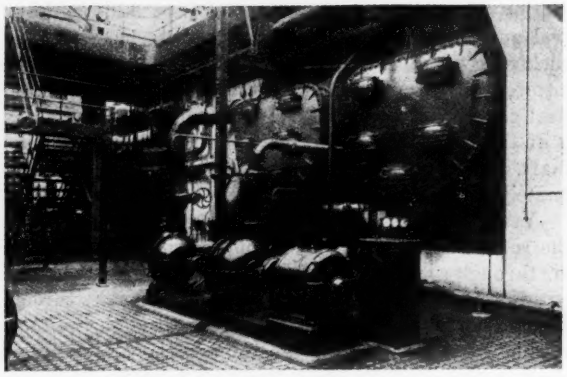


FIG. 5. CONDENSING EQUIPMENT

gases from each pair are handled by means of one fan and one stack. The exhaust fans are of the turbine type and driven by 65-hp. electric motors, producing a normal draft of 0.69 in., which, at 25 per cent overload on the boiler, is increased to 0.9 in.

The normal evaporative capacity of one boiler is 30,000 lb. of water into steam at a normal pressure of 210 lb. gage and a temperature of 600 deg. F. (207 deg. F. superheat), using Victorian black coal of 11,000 to 12,000 B.t.u. per lb. Steam passes from the boilers

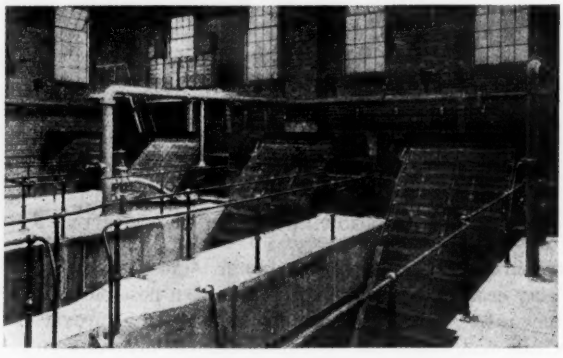


FIG. 6. THE TRAVELING WATER SCREENS

to four common 13-in. headers, located one in back of each row of boilers, thence into four receivers in the pump house basement. These four receivers are interconnected so that when changing the load from one turbine to another, it is unnecessary to change boiler connections. Figure 4 is a view of one of the boiler rooms. The floor is paved with a grooved, red brick.

Four reciprocating pumps with a capacity of 30,000 gal. per hour and four steam-driven centrifugal pumps with a capacity of 35,000 gal. per hour, are provided for boiler feed purposes.

### Coal and Ash Handling System

Over the firing space between the two rows of boilers in each boiler room is the coal bunker, which is made of steel and lined with concrete. Each bunker has a capacity of 1500 tons. Coal is unloaded from the cars into a hopper, whence it is carried, by means of a bucket conveyor, either to the storage pile or to the boiler room bunker, as may be necessary. The coal can, if necessary, be passed through a breaker on its way from the hopper to the conveyor, which carries it to the boiler house bunkers. The coal is fed by gravity from the boiler room bunkers to the receiving hoppers of the chain grate stokers.

A roomy basement is provided in each boiler house, in which the ashes are dealt with. Ash bunkers are provided under each boiler capable of storing an

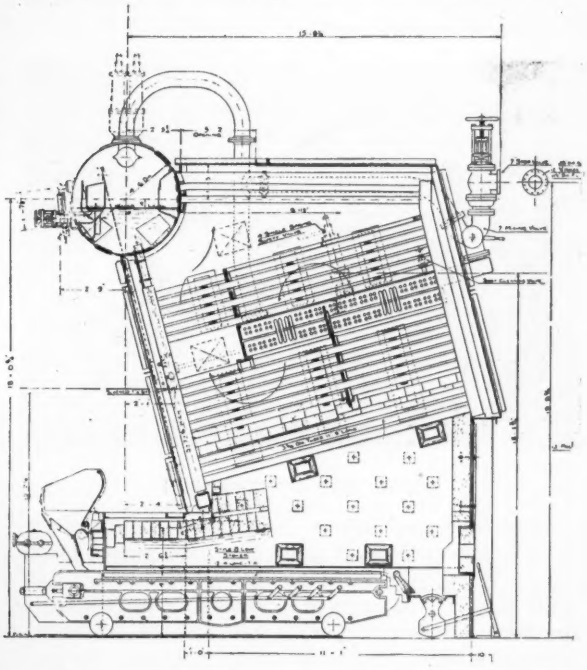


FIG. 7. SECTION THROUGH SETTING OF MARINE TYPE WATER-TUBE BOILERS

accumulation of ashes over some 12 hr. or so at full load, so that at ordinary load each bunker need be cleaned only once in 24 hr. Below the ash bunkers is a narrow gage track on which a clinker crusher can be moved from bunker to bunker. The crusher discharges into a pipe through which the ashes are conveyed by air suction to the elevated ash receiver outside. Two exhausters for producing the suction are installed in each boiler house basement, each driven by a 60-hp. electric motor.

### The Turbine Room

The turbine room, which has normal accommodation for six units—of which only four have been installed—has a railway siding running into it under an overhead bridge crane having a capacity of 60 tons at 7½ ft. per minute, or 20 tons at 20 ft. per minute, with an auxiliary hoisting gear capable of lifting 5 tons at 40 ft.

per minute. The siding passes through an annex which will be fitted up as a machine shop with a few machine tools for light repair. This annex is provided with a 15-ton, hand-operated crane.

Erected on foundations standing on the basement of the turbine room are the foundations for the turbines, under each of which are two twin surface condensers, each having a total of 22,000 sq. ft. of cooling surface, with tubes 1 in. outside diameter and 12 ft. 6 in. in length. Between the turbine foundations are the kinetic air and water extraction pumps, each mounted on a bed plate with, and operated by, an 80-hp. motor running at 750 r.p.m. These pumps were designed to maintain a vacuum of 28.75 in. with the barometer at 30 in., when dealing with 120,000 lb. of water per hour. The condensate is delivered into a main feeding the heaters in the pump house, which are normally in parallel with hot well tanks, having a storage capacity of 12,000 cu. ft. The condensing equipment is shown in Fig. 5.

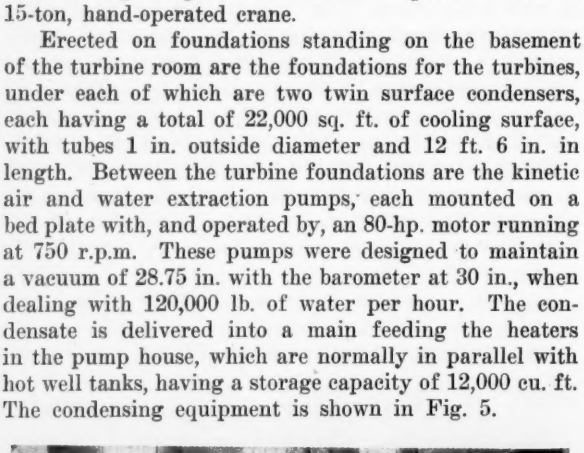


FIG. 8. THE CONTROL ROOM

In the basement are the turbine oil coolers, the oil filters and the oil coolers and circulating pumps for the step-up transformers, the pumps for circulating water to the wet air filters, and the alternator ventilating fans. The basement floor is paved with grooved bricks of a deep red color.

The turbine operating floor is 22 ft. above the basement floor and is reached by staircases between each pair of turbines. The floor is tiled throughout, and the walls are also tiled to a height of 7 ft. The concrete turbine foundations are given a smooth finish, presenting a good appearance and a surface to which little dust can adhere.

On a platform above the hot wells is installed a 4000-gal. tank, mounted on a weigher. Into this tank the condensate from any condenser may be pumped to determine the steam consumption of the turbines.

## Generating Equipment

THE STEAM turbines are of the reaction type, running at 1500 r.p.m. The cylinder is divided, the high-pressure end being of the single-flow type, and the low-pressure of the double-flow type with center admission. "Puff" governing is employed, and the turbines are fitted with the customary automatic bypass and emergency valves. A novel feature is the absence of any rigid connection between the steam chest and the cylinder. This lessens the risk of undue stresses being put on the turbine, and has some constructional advantages, in that the metal in the casing can be more evenly distributed than in the usual design. Lubrication is provided by means of two rotary pumps driven by the governor spindles, and by the auxiliary steam-driven pump used in starting and stopping.

The alternators were designed to generate at a normal voltage of 3300 and a frequency of 25 cycles. The stator has 28 slots per phase and one conductor per slot. The slots are completely closed. The windings consist of cotton covered, stranded wire laid up to an oval and soldered to flat end connections, making rigid anchoring possible. The rotor is of the barrel type, with formed coils secured in slots by means of keys. Heavy steel caps hold the end windings in place. The exciter is of the four-pole type, direct-coupled to the alternator shaft. The total rotating weight of one unit is approximately 50 tons.

Ventilation of the generator is by means of fans on the rotor, supplemented by a motor-driven fan drawing air through a wet air filter and delivering into a chamber within the alternator foundation. The air passes through the end connection of the stator, then through the rotor, returning through passages through the stator into a sheet metal duct which delivers it to a brick uptake above the transformer house.

The normal capacity of each unit is 10,000 kw., the maximum continuous rating being 12,500 kw. at

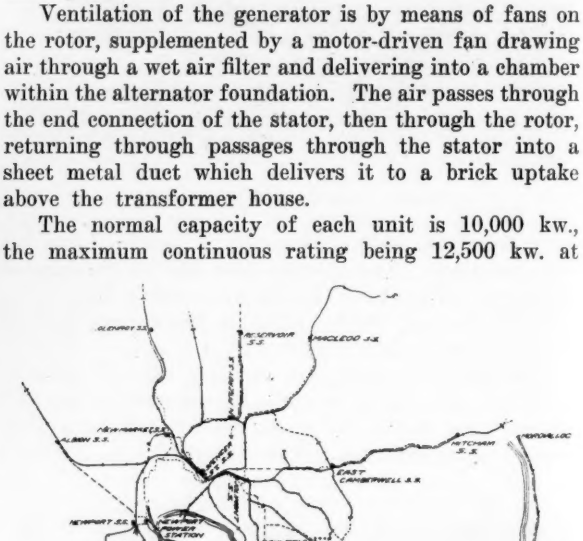



FIG. 9. MAP SHOWING TRANSMISSION SYSTEM

95 per cent lagging power factor. As a result of the delay occasioned by the war it has been possible to introduce into the two units yet to be installed improvements which will result in their maximum continuous output being increased to 14,000 kw. at 95 per cent lagging power factor.

## Auxiliary Generating Equipment

Two 350-kw. non-condensing turbines, generating three-phase current at 440 v., are installed in the pump house, mainly for the purpose of starting the condensing auxiliaries before putting into operation the main units.

Three-phase current at 440 v. is used throughout the plant for motive power. Each generating set is supplied with a 400-kv.a. transformer fed from the 300-v. generator leads. In addition to this source of supply for the auxiliaries, there will be found 1000-kv.a. station

transformers fed from the 20,000-v. bus bars, located two at each end of the switch house building in rooms provided therefor. Two motor-generators, consisting of 102-hp., 440-v., three-phase induction motors and 55-kw., d.c., 110-v. generators, direct-coupled with boosters, are provided for charging the lighting and control batteries.

### Transformer and Switch House

The unit and step-up transformers for each generator are installed in separate rooms in the transformer house. Each room is provided with a traveling crane, on which can be hung electrically-operated blocks, capable of traveling out over the railway tracks, through doors provided for that purpose. As the step-up transformers are single phase, three are installed in each room. The primaries are connected in delta to the bus bars from the alternators, and the secondaries in star to a set of bus bars on the wall of the transformer house. Current is delivered through paper insulated, lead covered and wire armored cables to the switch house.

All high tension switch gear is installed in the switch house at some distance from the engine room. On the ground floor are the terminal boxes of the incoming 20,000-v. cables and the outgoing feeders, potential transformers and isolating switches, all in brick compartments, separate for each generator or feeder, and are enclosed with expanded metal screens.

The second floor is set apart for oil switches, with current transformers for protective gear and instruments. The brick cells are here closed by steel doors, but the oil switches are open to the outside air through vents with automatic flaps which will exhaust any explosive gases which may be generated by the operation of the switches.

Supported on steel joists under the roof, over the passageway provided down the center of the switch house, are the 20,000-v. test bus bars which can readily be connected to any one generator when isolated from the main busses. Each section of the building contains a set of 20,000-v. bus bars which can be connected together by means of a 1500-amp. bus sectioning oil switch. All other switches are rated at 500 amp. Switches have separate tanks to each phase and are electrically controlled.

Feeder switches are of the split conductor type, the contacts being arranged so that the split conductors of each phase are connected together only when the switch is closed. The feeder earthing switches at each end of the 20,000-v. feeders are arranged so that upon the oil switch being open, the operation of the earthing switch will earth first one switch and then the other, the splits being connected at the substation end so that the earthing switch, when fully operated at that end, will earth the opposite split to that which is left earthed by the full operation of the earthing switch at the power station end.

The present plans provide for 15 substations, as shown in the map, Fig. 9, to which current will be transmitted at 20,000 v. Rotary converters will deliver 1500 v. direct-current to the overhead wire.

Data and illustrations used in the preparation of this article were taken from the Commonwealth Engineer.

# The Locomotive Crane in the Power Plant

### Notes on the Use of Steam and Electric Locomotive Cranes in Handling the Coal Supply

With the increased cost and decreased supply of labor comes a realization of the necessity of substituting machinery for manual labor wherever it is possible. While substitution has been in progress for a long time in the power plant itself by the installation of stokers in the boiler room and various types of automatic machinery in the engine or turbine room, the coal-handling system has, in many plants, been neglected. The most efficient boilers and generating equipment will not produce power at the lowest possible cost unless supplemented by efficient machinery and methods in the handling of the coal from the time the car is received.

There are a number of systems and types of coal-handling machinery, each one of which has its merits and particular field. When a new plant is built, the coal- and ash-handling equipment can, and should be, designed with, and as a part of, the power plant, and the type is more or less a matter of choice. In old plants, however, which were not originally equipped with efficient coal-handling equipment, the type or system to be installed is dependent upon local conditions, and requires careful consideration. In any case, whether the plant be new or old, that system should be chosen which will handle the coal from the car to the boiler at the lowest possible cost per ton, taking into consideration cost of upkeep, depreciation and, where necessary, first cost.

Among the various systems, those employing locomotive cranes in whole or in part may be cited as examples of flexibility and adaptability to various conditions. This is particularly true in large- and medium-sized plants, and those small plants in which provision has not already been made for efficient coal handling. Under present conditions, many plants which ordinarily do not carry a large reserve supply of coal, have adopted the practice of buying coal when possible and storing it in any available vacant space. The locomotive crane is one of the few available means of handling this temporary reserve in an efficient manner.

Locomotive cranes are procurable in various sizes and two general types, the steam and electric. Where the distance to be traversed is not very great, and special tracks can therefore be laid, and especially where operation is not continuous, the electric crane is of considerable advantage. No fuel loss is entailed by periods of idleness, and, as a consequence, maintenance costs are low. Where the distance to be traveled is great, and coal has to be brought from a point at some distance from the plant, and possibly loaded into a car for transportation, the steam crane is the more practical, as no dependence is placed on an external source of power. The locomotive crane is frequently used for emergency switching. When this is done, however, no saving is made in switching charges, as the mere fact that a car

was loaded and unloaded entitles the railroad to make such a charge; but time is saved in not having to wait for a switch engine. For switching purposes, cranes are fitted with link and pin couplings, and quite frequently with the standard M.C.B. automatic car coupler.

### Layout of the Plant

The relative locations of the boiler rooms, storage facilities and switch tracks are of much importance in the saving of time and effort. Lost motions should be reduced to an absolute minimum. Figure 1 shows how this has been done in the plant of the Metropolitan Water Board of Omaha, Neb. In this case, coal can be handled by means of the locomotive crane from the car to any part of the pit desired, and just as easily transferred from the pit to the boiler room hoppers,

FIG. 1. HANDLING COAL AT THE PLANT OF THE METROPOLITAN WATER BOARD, OMAHA, NEB.

located in the roof. The pit is of a size sufficient to hold a large reserve supply, and, being of concrete, it can be flooded with water, should that be necessary.

At the plant of the Dexter Portland Cement Co., Nazareth, Pa., a different method is employed. Here a locomotive crane is used to unload cars, and to handle the coal from the storage pile to a bin located above the coal crusher. Coal is carried to the boiler room by means of a conveyor system. This layout is shown in Fig. 2.

An interesting installation is in use at the Spy Run power plant at Fort Wayne, Ind., Fig. 3, where a 10-ton electrically-driven crane is employed, equipped with a 30-ft. boom and a 1-cu. yd. V-type clam shell bucket. Coal is handled either from car to pit or from car to a four-roll crusher. The crane has a capacity of 40 tons per hour of mine run coal from car to crusher or 60 to 80 tons of slack coal from car to pit. This is a typical case where a special track has been built over the pits for the crane and crusher.

### Flexibility of the Locomotive Crane

In medium-sized and smaller plants where the amount

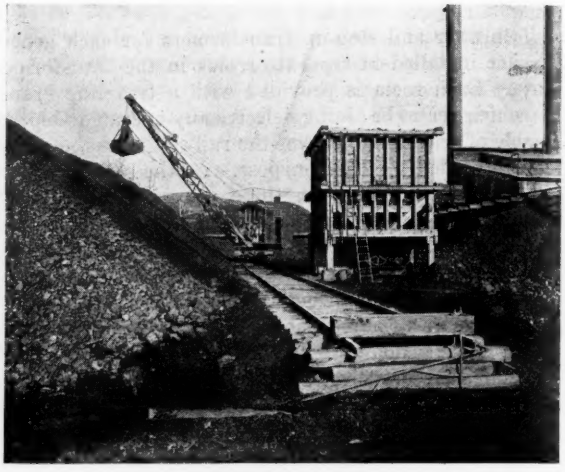


FIG. 2. STORAGE PILE, BIN AND CRUSHER AT DEXTER PORTLAND CEMENT CO.'S PLANT, NAZARETH, PA.

of coal burned does not require the use of a crane all day, the question may arise as to how to eliminate the idle periods. In the industrial plant this question is easily answered as, without doubt, there is other material to be loaded or unloaded, such as sand, gravel, lumber, heavy castings, etc., as well as material to be transferred about the plant. Detachable buckets which may

FIG. 3. ELECTRIC LOCOMOTIVE CRANE AND COAL CRUSHER, OPERATING ON SPECIAL TRACK, SPY RUN PLANT, FORT WAYNE, IND.

be removed when not in use, help to solve this question. Furthermore, the locomotive crane can be used with equal facility either inside a building or outside, and it can, therefore, be used on many repair jobs in the boiler or engine room, if tracks are available in the building. Given good, solid tracks, the locomotive crane can handle any job within its lifting capacity.

Two types of grab buckets are in common use with locomotive cranes: the clam shell and the "orange peel." The former, which is suited to work with loose materials, such as coal, gravel, etc., is available in the two-cable type, Fig. 4, which employs an auxiliary cable and hoist for opening and closing the bucket, and the single-cable type which, as its name implies, utilizes only one cable.

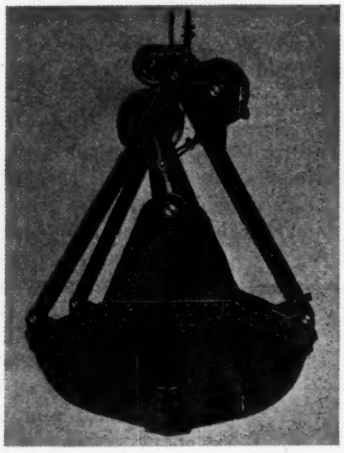


FIG. 4. ONE FORM OF THE TWO-CABLE TYPE GRAB BUCKET

The single-cable type of bucket is provided with a sling, which is thrown over the regular crane hook. The grab bucket shown in Fig. 5 is opened by means of the hand line shown, which operates a trip, allowing the bucket to open by force of gravity. To eliminate the shock which would otherwise be imposed on the crane by the sudden release of the load, the hoisting lines are attached to one side of the bucket in such a

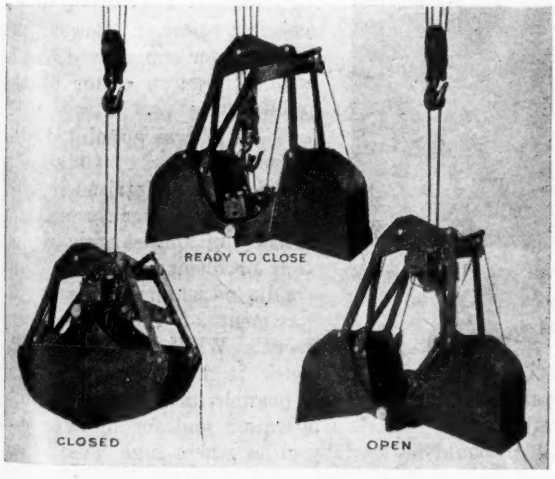



FIG. 5. A GRAVITY-OPERATED, SINGLE-CABLE GRAB BUCKET

way as to cause the grab to climb its own hoisting cables. The grab is now in the position marked "open." When the bucket comes in contact with the material to be handled, the crane block passes downward through the framing, as in the position marked "ready to close," and allows the trip to be re-engaged. Pulling upward on the cables then closes the bucket. The "orange peel" bucket is hemispherical in shape and opens in four parts. It is used mainly for excavating work.

There are a number of time saving accessories available for other classes of work, such as special forms of hooks, gripping devices, etc. When most of the work to be done is other than coal handling, it is advisable to have the crane normally equipped with the ordinary type of hook, and use for coal handling a bucket of the type which requires only to be slung from the crane hook. This type of grab bucket may be either mechanically or electrically opened and closed.

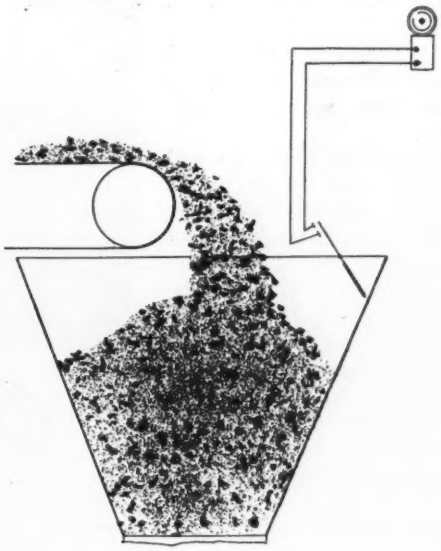
### Safety

THE LOCOMOTIVE crane requires a more highly trained operator than any other form of crane. Given such an operator, who knows his machine thoroughly, and a good roadbed over which to travel, danger of accidents is reduced to a minimum. It is the practice in the larger plants, however, to have a switchman or conductor accompany each crane on all jobs. This is absolutely necessary where any switching of cars is to be done; otherwise it is at least advisable as a safety precaution, as few cranes are so constructed that the operator has an unobstructed view from the rear of the cab.

## Alarm for Coal Storage Hopper

By M. A. Saller

THE use of overhead coal conveying systems has brought into general use overhead storage bins or hoppers for holding a supply of coal above the stokers. Frequently these are filled by automatic conveyors which distribute the coal along the entire battery,



ARRANGEMENT OF ALARM ON HOPPER

in which case it is necessary to know when one bin is filled so that the discharge can be adjusted. To eliminate the necessity for climbing up to the bin every once in a while at the time of filling, some arrangement, as shown in the sketch, could be used. As soon as the level of coal in the hopper reached the "full" point, it would press against the paddle, which, in turn, being pivoted, would close the electric circuit to an alarm bell.

# OSBORN MONNETT

WITH A PURPOSE AND A PLAN, THIS YOUNG MAN TRAINED HIMSELF TO HANDLE BIGGER OPPORTUNITIES. NOW A RECOGNIZED AUTHORITY ON SMOKELESS COMBUSTION. BY WALTER PAINTER

"BY OSBORN MONNETT" has been the subcaption of many a splendid article appearing in engineering journals during the past 15 yr. From the pen of this competent, self-made power plant engineer have come helpful talks upon every phase of steam engineering from boiler explosions to valve gear operation.

To an intimate acquaintance he recently admitted that there was never any question concerning the character of his vocation. "From the first," he said, "prime movers have been my hobby and I could scarcely take time enough away from the study of steam engineering subjects to get through grammar school, which was as far as my regular education extended. Long before this point was reached, I had a well defined ambition to become the best operating steam engineer in the country.

"Having my living, as well as my education, to get, I laid out a plan embracing as nearly as possible what would be required in the way of education and experience to meet the developments of the future.

"To be a successful engineer in the first quarter of the twentieth century, I believed that one would have to have a basic mechanical, electrical and chemical engineering education, and that, as the years progressed, refinements in the art of prime movers would become more and more of a chemical nature, or at least would be based upon processes of a more scientific character. Placing myself in a position where I would be on the firing line and capable of appreciating the problems and grasping the developments as they occurred, was my first idea."

In 1899 his plan was launched. Deciding that marine work offered the best steam engineering training, he went to work for the Wilson Transit Co., of Cleveland. In the following four seasons he filled the positions of coal passer, fireman, water tender, and oiler at $33 a month. While standing a 6-hr. on and 6-hr. off watch, he studied electrical and mechanical engineering and analytical chemistry.

This gave him valuable experience with large steam units, Scotch-marine boilers and triple-expansion engines, as well as practical steamfitting, emergency repairs and self-reliance. He took a postgraduate course in practical chemistry at the laboratory of the American Steel & Wire Co. of Cleveland and entered stationary power plant practice in Ohio, later going into the Rock Island Railroad repair shops at Silvis, Ill., where, for 4 yr., he had an opportunity for further study of the latest methods and refinements in power plant operation.

In 1907 he joined the editorial staff of "The Engineer," of Chicago, concentrating on practical steam power plant subjects. In 1908 New York called him as associate editor of "Power," but he was later transferred to Chicago as western editor of that publication.

Next he was appointed chief smoke inspector of Chicago by Mayor Carter Harrison in 1911, and was thereafter thrown more directly in contact with combustion problems, the work being conducted as an engineering department of the city government. While engaged in this work it was his endeavor to standardize as much as possible the matter of boiler settings for smokeless operation and formulate a code which could be used by cities where high volatile coal was the principal fuel. The Chicago code has since been extensively copied and is now being employed in many important cities of the country.

For three years following the termination of Mayor Harrison's administration, he was identified with the American Radiator Co. in an advisory capacity on smoke abatement matters and in practical engineering research. During this period he lectured on combustion and efficiency methods before chambers of commerce and various civic bodies in most of the principal cities

of the country, as well as before the mechanical engineering classes of various universities.

In 1917 he was chosen a member of the conservation committee of the Illinois Fuel Administration and in 1918 joined the engineering staff, Conservation Bureau, U. S. Fuel Administration, at Washington, serving until the end of the war.

At present Mr. Monnett is engaged in private consulting practice, associated with the Commercial Testing & Engineering Co., of Chicago, and also with Griggs & Myers, consulting engineers, of New York. In connection with his present activities, he has been recently retained as consulting fuel engineer for the Bureau of Mines, for the purpose of directing an investigation of the atmospheric conditions of Salt Lake City.

He has constantly endeavored to keep abreast of the art and to appreciate the trend of future developments. Due to his active interest in marine matters, naval architecture and allied subjects, he was called on for consultation during the war and remained in touch with the Ship Protection Committee of the Naval Consulting Board on matters relating to the reduction of visibility of steamers using high volatile coal.

David Moffett Myers says "his personality inspires a confidence that is well placed. He is a delightful companion in work and play and a corking good cruising mate, which is probably the warmest tribute that one yachtsman can render another."

Mr. Monnett thoroughly enjoys studying the history of power plant engineering, and when his leisure moments are not spent browsing around some library looking up the development of steam power and its various applications, he is usually found taking photographs of unusual subjects, such as snow scenes and lighting effects.

# The Centrifugal Pump

### A Simple Explanation of Its Theory, Together with Hints on Installation and Operation

DUE TO the fact that the centrifugal pump is a relatively high speed machine and that there was no motive power well suited to it, it was not considered seriously until recent years.

With the introduction of the electric motor and steam turbine, conditions have changed. These high speed machines furnished an excellent means of drive and stimulated the development of the centrifugal pump. Today the demand for this type of machinery is steadily increasing, and in the power plant where steam turbine-driven centrifugal pumps form most of the auxiliaries they are rapidly gaining in popularity.

Pumps that depend for their action upon centrifugal force, or the variation in pressure due to rotation, are termed centrifugal pumps. These may be divided broadly into two classes: (1) volute pumps, and (2) turbine pumps.

A volute pump is one in which there are no diffusion or guide vanes, but, instead, the casing is spiral. This spiral casing, or volute, as it is sometimes called, guides the water as it leaves the impeller to the discharge pipe passages whose function it is to convert the velocity of the water leaving the impeller into pressure.

A turbine pump is one in which the impeller is surrounded by a circular diffuser which contains ribs, called diffusion vanes, forming water passages. These vanes are so shaped that they provide gradually enlarging passages whose function it is to convert the velocity of the water as it leaves the impeller into pressure.

Centrifugal pumps are further classified as single-stage or multi-stage pumps, according to whether there is but one impeller or whether there are two or more impellers through which the water flows in series.

## Theory

A BOY whirling a pail of water about his head and not spilling a drop provides a good illustration of the theory of action of a centrifugal pump. The force that holds the water in place against the bottom of the pail is called centrifugal force.

Now, suppose that a hole is punched in the bottom of the pail. A stream of water will flow out. That stream would be continuous if the boy's arm were a pipe supplying water to the pail.

If we substitute for the boy's arm a suction pipe, for the pail an impeller throwing a stream and if we then build a casing to guide the stream in one particular direction to a discharge outlet, we have a centrifugal pump.

In determining the speed of the impeller in a cen-

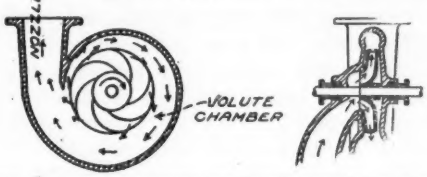



FIG. 1. VOLUTE TYPE OF CENTRIFUGAL PUMP

trifugal pump, we make use of the law of falling bodies, which states that

$$V^2 = 2gh$$

In which V = velocity of the moving body in feet per second.

g = acceleration of gravity, 32.2 feet per second.

h = head in feet, or distance through which it falls.

The water, as it leaves the impeller to be thrown to a certain height, must have the same velocity as it would if it fell from that height. This law may be stated as follows:

The speed in feet per minute of a point on the periphery of the impeller should be equal in velocity to water falling from the same height as the head pumped against.

Let us take an example:

The impeller of a certain pump is 13.5 in. in diameter. At what speed must the pump operate to deliver water against a 120-ft. head? Substitute this head, 120 ft., in the formula.

$$V^2 = 2gh$$
$$V^2 = 2 \times 32.2 \times 120 = 7728$$
$$V = 87.9 \text{ ft. per second, or}$$
$$87.9 \times 60 = 5274 \text{ ft. per minute}$$

Therefore, we find that a point on the periphery of the impeller must have this speed. The number of feet in the circumference of the impeller is

$$\frac{3.1416 \times 13.5}{12} = 3.54 \text{ ft.}$$

The speed of the impeller then must be

$$\frac{5274}{3.54} = 1490 \text{ r.p.m.}$$

From the foregoing it is plainly seen that, with the same conditions of head, the smaller the diameter of the impeller, the greater must be the speed of the pump, and vice versa.

The capacity of the pump, however, depends on the size of its openings—suction and discharge—and on the size of the casing. It also depends on the width of the impeller vanes, just as the larger the hole punched in the bottom of the pail, the more water discharged. The pump is only allowed to pass an amount of water that will not cause undue friction losses due to high velocity. It is safe to say that the velocity of the water at the discharge of the pump should be about 10 to 12 ft. per second.

In studying the relations that exist between head, capacity, speed, etc., we make use of the so-called affinity laws that govern the action of centrifugal pumps. These are listed below.

When the diameter of the impeller remains the same:

(1) The quantity will vary as the speed.
(2) The head will vary as the speed squared.
(3) The power will vary as the cube of the speed.

These effects are obtained by changing the speed, but the size of the impeller is kept the same.

However, if we hold the r.p.m. constant and change the diameter of the impeller, we find that:

(4) The quantity varies as the diameter.
(5) The head varies as the square of the diameter.
(6) The power varies as the cube of the diameter.

So far, we have been considering only the single stage or single impeller pump. We have considered the water entering the pump and impeller to have had practically no pressure.

Suppose we had two single-stage pumps, each running at 1490 r.p.m. and each discharging water at a 120-ft. head. According to our calculations, the velocity of the water, as it leaves the impeller of either pump, would be about 5274 ft. per minute.

Now, suppose that the discharge of one of the pumps was connected to the suction of the other. We would find the velocity of the water leaving the impeller of the second pump to be 5274 ft. per minute plus the head of 120 ft. produced by the first pump, or, in other words, the second pump would be delivering water against a 240-ft. head.

If three or four pumps were connected in this manner, the resulting head would be the sum of the heads of all the pumps. This is really a multi-stage pump and the principle upon which all such pumps operate.

The commercial multi-stage pump has all the impellers mounted in a single casing for the sake of simplicity, economy and compactness, but the action is identical with the example just quoted.

In regard to the suction of a centrifugal pump, let us first consider the action in a reciprocating pump. The plungers, or pistons, occupy a certain amount of space. As the plungers move, the space occupied by them becomes a partial vacuum. Due to atmospheric pressure on the surface of the supply, the water below rises and fills the space made vacant by the plungers and the pump starts to discharge water. Because of this positive action or displacement feature, this type of pump seldom requires priming.

In a centrifugal pump this is not the case. The impeller may revolve, but the air which fills the casing is not discharged. Before the pump will start to discharge it is necessary to displace the air from the casing of the pump by some method. This is called priming.

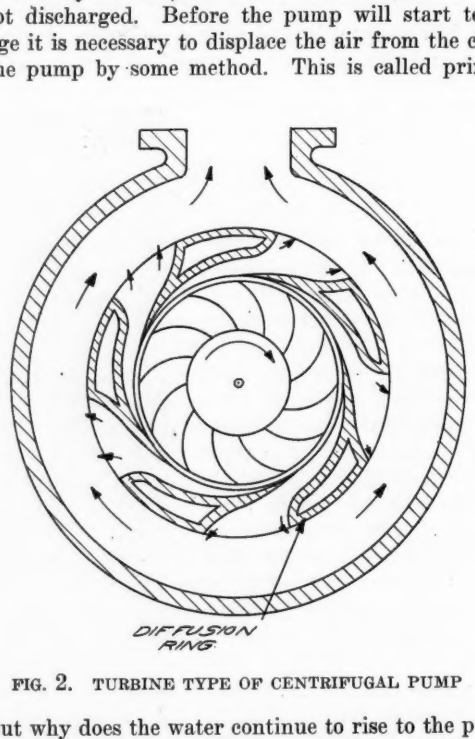



FIG. 2. TURBINE TYPE OF CENTRIFUGAL PUMP

But why does the water continue to rise to the pump, once it is in operation? This is best illustrated by the following example:

Imagine a pump full of water and at rest. When the impeller is revolved the water contained therein is thrown outward, due to centrifugal force, and the displacement of this water creates a partial vacuum. This is immediately occupied by more water entering through the suction pipe, due to atmospheric pressure on the surface of the supply. Instead of the moving portion or plunger of the reciprocating pump, we have water moving out of the impeller. The action is continuous and, therefore, the pump remains primed and continues to discharge.

## Installation

Although not requiring the heavy foundations necessary for reciprocating machinery, the centrifugal pump will give the most satisfactory service if it is installed upon a good, substantial foundation. The pump should be placed as near the source of water as possible, especially when operating with a suction lift. If possible,

place the pump below the water level in the suction reservoir, so that water will flow into the pump by gravity, thereby making the pump self-priming.

In case of operation with a suction lift, the pump should not be higher than 15 ft. above the water level. A suction lift of more than 20 ft., including pipe friction head, should never be attempted.

Pipe friction must not be overlooked when selecting pipe sizes. It is usually advisable to reduce pipe friction to a minimum by selecting a larger pipe, as the first cost of the larger diameter pipe will soon be returned by the saving in power. All unnecessary elbows and fittings should be avoided, as they all tend to increase the pipe friction.

Do not use suction piping smaller than the suction opening. If the suction lift exceeds 15 ft., use pipe a size larger than the suction opening. Always place the end of the suction pipe at least 3 ft. below the surface of the water in the suction well to prevent air being drawn into the pump. When the pump is placed below the water level in the suction well or when it takes water from a system of piping in which pressure exists, it is always necessary to place a gate valve in the suction line close to the pump, so that the pump may be removed, or shut down, for repairs. A centrifugal pump should never be installed to take its suction from a battery of driven wells, as the pump is very likely to exhaust the wells nearest to it and then air will be pulled in through the suction pipe, thereby causing the pump to drop its suction.

When pumping water containing such a percentage of air as to break the suction lift at times, the trouble can often be overcome by placing an air chamber in the suction line of the pump and connecting the top of this chamber to a vacuum pump. Care should be taken, however, to run the pipe up vertical a distance of at least 35 ft., so that there will be no danger of any water passing over into the vacuum pump if a dry vacuum pump is used (Fig. 3).

The size of the discharge pipe should be determined by taking into account the pipe friction losses, although there has been a certain tendency to use the same size discharge piping as the discharge opening of the pump, regardless of the length of the pipe line.

A gate valve and a check valve should be installed in the discharge pipe as close to the pump as possible. The gate valve is used principally to control the capacity of the pump, while the function of the check valve is to protect the pump casing from breaking due to water hammer.

## Operation

In conclusion, a few words may be said regarding the operation of centrifugal pumps. While the centrifugal pump can be run with its discharge valve entirely closed without generating a pressure much in excess of its rating and without breaking the casing or discharge pipe, it should not be kept running for longer than 15 or 20 min. at a time under these conditions. When the valve is closed, the pump slightly churns its water and if this is continued too long, the water will become heated to a dangerous degree. To prevent the water from becoming heated when operating under this condition, a small relief valve and bypass line should be installed so that a small amount of water can pass through the pump. When running against "shut-off," as the above condition is termed, a centrifugal pump requires from 35 to 50 per cent of the power consumed when pumping at its economic capacity.

When in operation a centrifugal pump is usually nearly noiseless. Sometimes, however, it will produce a rattling sound, varying in intensity. This is caused by the pressure of air in the pump and can be remedied by opening the air cocks at the top of the pump casing. The noise may also be caused by operating the pump at a lower head than that for which it is designed. The rattling and vibration are caused by a distortion of the flow lines in the pump and the remedy is to close the discharge valve partially, thus increasing the head artificially, and restoring the original hydraulic conditions.

Noise can also be caused by running a pump in the wrong direction, with practically the same effort as regards the flow as in the preceding paragraph. The remedy is obvious: change the direction of rotation.

Sometimes when a pump is operating on a suction lift, it will lose its water, or priming. This is generally

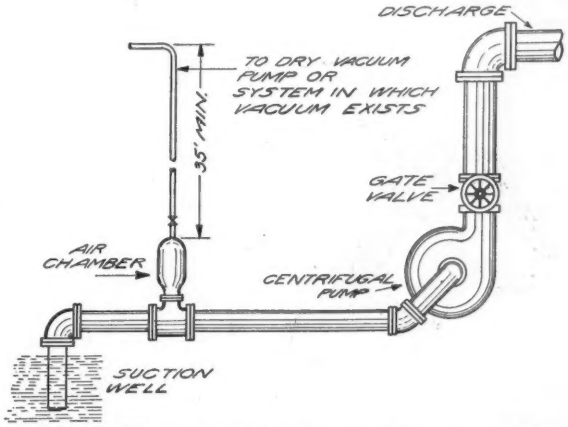



FIG. 3. METHOD OF TAKING OFF AIR IN SUCTION LINE

due to the gradual accumulation of air in the casing, which has been drawn in through a leaky suction pipe. There are times when the pump will work properly until the discharge is throttled, and will then "let go." This is due to a small air leak, not serious so long as the full capacity is discharged and a relatively high velocity of water maintained through the suction pipe and casing, thus conveying the air through, and not allowing it to accumulate. The remedy is to examine the suction side of the pump for air leaks.

A good way to do this is to put the casing and line under hydraulic pressure.

Many forms of centrifugal pumps are on the market, each designed to operate under certain conditions. The purchaser of a pump must first ascertain all the conditions under which the pump will have to operate, and from the data thus collected he will be able to determine which type and size of centrifugal pump to buy.

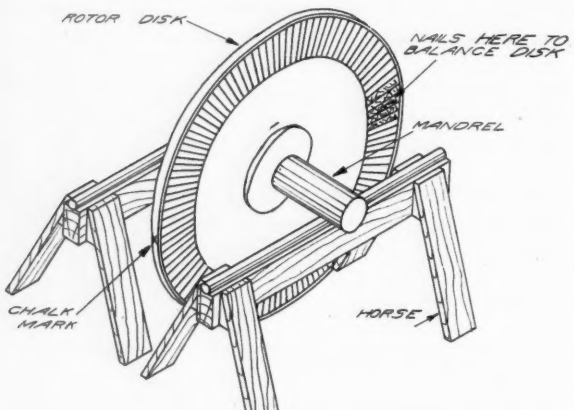
Much of the data used in the preparation of the foregoing article was taken, by special permission, from the confidential sales data sheets of the Goulds Manufacturing Co., to whom credit is hereby given.

# Correcting Turbine Balance

After Three Men Had Tried, the Fourth Finally Cured a Bad Case of "Critical Point." By Jay C. Wheeler

THE INTENTION of this article is not to cast reflections on any turbine manufacturer, but solely to aid the operating engineer as well as the employer of such operating engineer, so that he and they may secure the best possible and efficient operation.

I have had occasion to note such expressions as: "A turbine is a very simple piece of machinery, but only to those that thoroughly understand it." "Do not be afraid of a turbine because it runs at high speed." "Many engineers are totally unfit to operate a turbine because they are afraid of it." "Nobody will thoroughly understand a turbine who does not study a turbine through the turbine itself as well as through all books obtainable" and "Turbine manufacturers expect trouble with units in charge of incapable engineers."




METHOD OF BALANCING ROTOR DISKS

We will agree with the manufacturers that a turbine is a simple piece of machinery, agree that we should not be afraid of it, because it runs at high rate of speed; but we will not agree that many engineers, in fact we should use the word *any* instead of *many*, are totally unfit to operate a turbine because they are afraid of it. We will admit that there are some operatives who are totally unfit to be around a power plant, much less to operate a steam turbine. There are reasons for this condition, however, and we shall not go into those reasons at this time.

We believe that every turbine manufacturer has a greater or less interest in his machine, and will do all within reason to cause the unit to operate satisfactorily. However, we have seen time and again a turbine and driven unit shipped to a customer and then comes along an erecting engineer who was more or less inexperienced and mechanically unfit to erect the unit, although the manufacturer will say: "It is desirable to have the operating engineer on each shift spend as much time with our erecting engineer as possible, so that they will have an opportunity of seeing how any adjustment is made and to ask questions regarding any point about which they are in doubt." Now, with such an erecting engineer on the job, how can we learn and thoroughly understand the unit, when our teacher is lacking?

We have noted instances where, after the unit was ready to start up, and turbine was thoroughly heated up, that vibration would appear at a certain point. We have asked the question, "Why?" We have been informed that it is a critical point which will soon vanish. We have been informed that when this point is about to be reached, the turbine is to be run slowly until over the point. We have followed the instructions for a time until the oil piping is shaken loose and broken off and our back teeth are nearly dislodged. Then we get busy and have the manufacturer send us an erecting engineer to assist us in retaining our equilibrium.

Along comes a second erecting engineer, who advises us that when this point is reached, the turbine is to be gotten over this critical point quickly. This second erecting engineer proceeds to jump the turbine quickly across the critical point and sometimes succeeds for the time being. We still complain of the vibration and he politely informs us that this will vanish shortly. Then he packs up and leaves. We scratch our heads and get to thinking that we ourselves are mentally deficient, as well as mechanically. We humor the turbine along for a while, but still the vibration does not cease; in fact, it appears to be on the increase, our packing begins to leak, our oil pipes begin to leak, the driven unit gets erratic and we are brought on the carpet for an explanation why we are not getting efficient results. We are up a tree, as one might say. Number one engineer advised us to creep across this critical point and number two advised us to jump this critical point as quickly as possible. We have followed both instructions to the letter and yet we are no nearer results than we were the day the unit arrived on the cars. We begin to think that a turbine must be full of critical points and only a critic can get over the critical point. Well, we wire again for an erecting engineer to come and solve our troubles.

This time, number three arrives and after looking wise for an hour or so, he wants to know how long the unit has been in operation, what kind of oil we are using and a hundred other questions of a like kind. We give him all the information we have and in a short time he advises we have a bent shaft, caused by using improper oil, thereby causing excessive wear of bearings, thereby causing misalinement and so on down the line have we done so many things that we begin to think we are *non compos mentis*. Then we hold a consultation with our employer and this erecting engineer, in which we are hauled over the coals without any regard to our feelings; new material is ordered, the erecting engineer departs and we go back to our pet thinking all manner of things good, bad and indifferent.

In due course of time along comes the new material, also erecting engineer number four. (Gee! they must have an array of traveling gentlemen erecting engineers). We now have had four erecting engineers on the job, the unit has been installed over six months, we have gotten no service from the unit, and yet we

"are unfit to handle a turbine because we do not thoroughly understand the turbine."

Well, number four starts out to disassemble the unit and install the new parts, which new parts were made necessary to install by our incompetency. He is sure a gruff fellow. He appears to be deaf. Our questions appear to have no meaning to him, yet we are admonished to go along with the erecting engineers and ask questions regarding any point we do not understand. We may ask some queer questions because we have never seen or operated a turbine before and we are desirous of gaining all the knowledge possible. We note, however, that this number four erecting engineer will take nothing for granted. We believe he was originally from Missouri, because he has to see everything for himself. We note that he has checked up the bent shaft and finds that the shaft is not bent, he then checks up the couplings for concentricity and he finds that the outside turn of coupling is not concentric with the bore or shaft fit. He checks up the coupling bolts bolt circle and he finds that in drilling and reaming the holes somebody had gone astray. We noted when he removed the coupling bolts that he had to drive them out with a sledge hammer; but before driving them out, he used wedges between the coupling and the pedestal. We noted that he looked at these bolts and bushings for a considerable period. We ventured to ask a few questions, but he appeared not to hear us. We wanted to know whether the instructions contained in the book sent with the turbine was correct, said instructions reading: "All coupling bolt bushings must fit free on bolts and in coupling." We had noticed that when these bolts and bushings were installed by number one engineer, that he had difficulty in installing them and he used a heavy hammer to drive the bolts in place, and we thought probably the instructions contained a typographical error. We note now that the coupling bushings are worn badly eccentric. We note that number four gazes longingly at the coupling bolts and then asks if we have a pair of beam scales handy. We have the scales handy and we are at a loss to know why he wants beam scales? Does he want to weigh the bolts? Why would not any scale do to weigh the bolts on? We are scared stiff and dare not ask any pertinent questions. We bring the scales into the turbine room, and we keep our eyes peeled, so as not to lose anything that may assist us in *thoroughly understanding our turbine.* Well, he takes the platform balance weight off and hooks on a piece of wire, then hooks a coupling bolt onto the wire and moves the beam weight to and fro until he gets the bolt exactly balanced. He locks the beam weight at this position. Then he takes off the bolt and places another bolt onto the wire. This time, the beam goes clear up. He repeats this performance until he has tried out all the coupling bolts, and we believe he finds that the bolts were not in true balance with each other. He then tries out the coupling bolt nuts and coupling bushings in the same manner, and again he gets results something like he did with the bolts. He throws all the bolts, nuts and bushings into a box and says nothing and we dare not ask the why.

He starts disassembling the turbine rotor, he having heretofore disassembled the top half of the casing, our turbine being known as a split case turbine. We now see that a turbine is a very simple piece of machinery. The wheels, disks I believe he calls them, look just like the windmill down home on the farm. Gee, but we are interested! But we dare not ask any questions. We note that he is keenly observing a wheel. He asks us if we have a machine shop handy. Wonder what he wants a machine shop for? We do not have an up-to-date machine shop, but we do have an old engine lathe that we resurrected from the scrap pile and an old blacksmith's bench drill. Awestricken, we show him our machine tools and then at his request we direct him to our junk pile. He finally finds a piece of scrap to his liking and we take it into the shop for him. He gets busy with the lathe and makes himself an arbor, he calls it. And how he does make the chips roll off that chunk of steel. After getting his arbor finished, he asks us for some horses. Now, what he wants with horses we do not know and it is all we can do to keep from snickering and showing our ignorance. We then scout around the plant and we find some timbers, some mud and some round iron. With these he builds himself something that he calls balancing ways. He plays with those balancing ways for quite a time and we all think that he is trying to hand us a frost.

Well, he finally got his ways to his liking, and then he placed a disk with the arbor in the shaft hole on the round iron of his balancing ways. We noticed that the disk would not stay still but would revolve backwards and forwards for a time, then would come to a rest. We noticed that he put a chalk mark at the bottom point. He then rolled the disk over a part of a turn and allowed it to come at rest again. He followed this procedure for several times, and as the chalk mark came in the same place each time, he asked for some nails, and then placed the nails diametrically across from the chalk mark. He kept putting nails in the things called buckets until the chalk mark and the nails were diametrically opposite in a horizontal plane and disk would remain stationary. Then he weighed those nails and then took the disk to the bench drill and drilled some holes adjacent to the chalk mark, but did not drill the holes all the way through, and we noticed that he drilled them on the side of the disk which we understood him to call exhaust side. He then returned the disk to the balancing ways and now it would not revolve at all. No matter where he placed the disk it remained stationary. He followed this procedure with all the disks, and we noticed that some he drilled and some he did not. We were beginning to learn thoroughly our turbine, just by keeping our eyes glued to his every movement.

He now started to put the disk back on the old shaft. We wondered at this; for our employer had bought a new shaft, since we had caused the shaft, which he was now going to use, to become bent. While he was putting these disks back on the old shaft, a box arrived and we hastily opened it. We found therein a coupling, a set of coupling bolts, nuts and bushings. We noted that this coupling had some small holes drilled in it, as also had the coupling bolts, and the erecting engineer had a trace of a smile on his face. After getting all the disks back on the shaft, he asked for the scale again and tried out all the bolts, nuts and bushings; this time they all balanced, as he called it.

He finally got all the parts of the turbine together again and was ready to start up. We were wondering what would happen with the critical point. Would he creep up to it or would he jump over it? We were all standing around in amazement; since we did not know our turbine. hence we could do nothing. He opened the throttle a little. The turbine started off. He let her run slowly for a short time. So far we could not find the critical point. According to the erecting engineer's tachometer the turbine was beyond the critical point as far as the speed point was concerned. He opened the throttle wider. The turbine ran faster. We noted that the turbine was then up to designed speed, but the critical point had not shown itself. He let the turbine run idle for quite a lengthy period. He did not seem to concern himself, whereas we were all on our toes. He shut down the unit, made some calculations and checked up the couplings. He put in the bolts and bushings. They slipped into place easily and freely. He started up the entire unit this time. He did not tarry with the throttle, neither did he open the throttle very quickly. We all waited for the critical point to pop up. The turbine and connected unit had been running 5 min. now and still the critical point had not shown up. He asked for the load. We gave him all the load there was, which was approximately ¾ of the rated capacity. Still the critical point did not materialize. He stuck around the next day, just as unconcerned as could be. Toward night he advised us that he was through, to put the new shaft away for a future time, that he would leave the unit to us for our own handling. He packed up and left. We failed to ascertain from him what became of the critical point. We asked him various questions pertaining to the unit, some of which he answered and some he apparently failed to hear.

Four erecting engineers have been on the job; all four have handled the unit differently; all four have advised or advanced different arguments, and yet we have not been advised definitely as to what became of the critical point.

We admit we are farmers, but we will advance the argument that the first three erecting engineers were erecting engineers in name only, the fourth was a thorough erecting engineer, and the entire trouble with the unit from the start was due to faulty workmanship in the beginning, since various parts were unbalanced. This caused vibration, diagnosed by two erecting engineers as the critical point and diagnosed by the third engineer as a bent shaft, caused by our negligence, and not thoroughly understanding the turbine, and the fourth erecting engineer would not admit what the exact trouble was. We, however, being of the kind once called "rubbernecks,"—now termed "observing"—noted what was done and we think we know now where the critical point went to. When the outfit was gotten in balance, there was no place for the critical point to lodge, so it vanished in the drillings from the disks and the new parts.

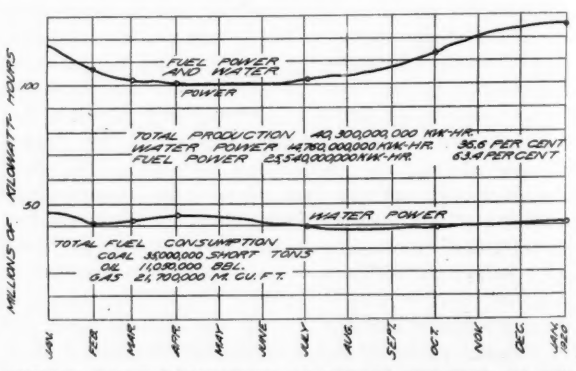
In my future articles I shall attempt to give the practical and efficient method of installing a turbine unit, beginning with the foundation and carrying you all the way through until the unit is permanently placed in service.

# Production of Electricity by Public Utilities

THE accompanying chart, compiled by the United States Geological Survey, gives some interesting data on the production of electricity, in the United States, in public utility plants during 1919. It will be noted that the figures for January, 1920, show a 15 per cent increase over the estimate for January, 1919.

The figures for January, 1920, are based on returns received from about 2800 power plants of 100-kw. capacity or more engaged in public service, including central stations, electric railways, and certain other plants which contribute to the public supply. The capacity of plants submitting reports of their operations is about 90 per cent of the capacity of all plants. The average daily production of electricity during January was 124,300,000 kw.-hr., 33 per cent of which was produced by water power.

The total production of electricity by public utility plants during 1919 was 40,300,000,000 kw.-hr., 14,760,-

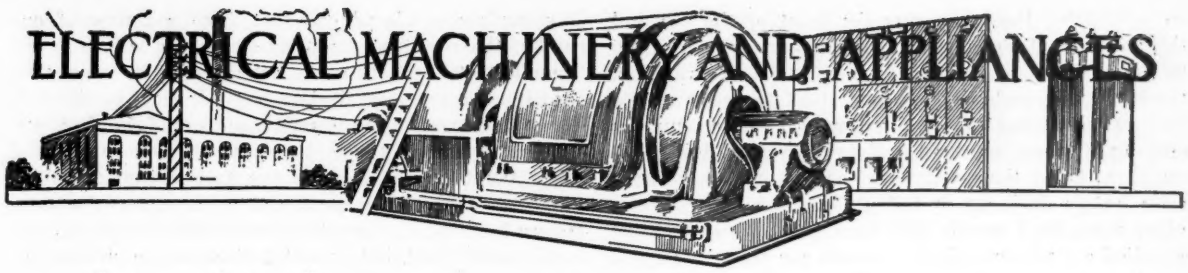



AVERAGE DAILY PRODUCTION OF PUBLIC UTILITIES IN THE UNITED STATES DURING 1919

000,000 kw.-hr., or 36.6 per cent, by water power, and 25,540,000,000 kw.-hr., or 63.4 per cent, by fuels. The curves are based on compilation of the total output for the following months: February, March, April, July, October, 1919, and January, 1920. The mean daily output for 1919 was 110,400,000 kw.-hr. The mean daily production for January, 1919, as shown by the curve, is about 108,000,000 kw.-hr.; the mean for January, 1920, was 124,300,000 kw.-hr., an increase of about 15 per cent. The value for January, 1919, is estimated.

The fuel consumption for the year was as follows: 35,000,000 short tons of coal, 11,050,000 bbl. of oil, and 21,700,000 cu. ft. of gas. Converting the oil and gas consumed to coal, the equivalent coal for all fuel consumed during 1919 would be 38,347,000 tons. With 25,540,000,000 kw.-hr. produced by fuels in 1919, an average of practically 3 lb. of coal were required per kilowatt-hour of electricity produced. On this basis, it would have required the consumption of 22,140,000 tons to have generated the kilowatt-hours produced by water power.

The estimated production of bituminous coal in 1919 is 458,063,000 short tons. The amount of coal used by electric public utility plants during 1919 was 7.6 per cent of the total produced.




# Industrial Illumination---I

DESIRABILITY OF PROPER LIGHTING; FUNDAMENTAL CONSIDERATIONS. BY VICTOR H. TODD

OF THE five special senses of the human body, the most essential to the pursuit of an industrial occupation is the sense of sight. This sense is practically indispensable for all classes of work (except a few minor mechanical operations) and to enable the sense of sight to function properly, it is essential that the objects which the eye must see are properly illuminated. Industrial managements are rapidly coming to realize that the eyes of the present and coming generations must be preserved and for this reason many lighting systems of only a few years ago, which were considered to be the best at that time, are now considered obsolete and are being rapidly replaced by modern systems, designed on a scientific and practical basis.

Not only on a humanitarian basis is scientific illumination of great value and profit to the industrial management. It has been shown repeatedly by authentic

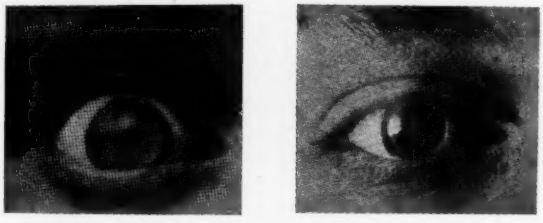


FIG. 1. APPEARANCE OF THE EYE UNDER INCORRECT AND CORRECT LIGHTING

statistics that a well-designed system will increase production, with the same labor costs. Some authorities claim an increase of as high as 20 per cent, while others conservatively place the increase at about 5 per cent, but in every case all agree that there is some increase, and undoubtedly the increase is largely dependent on the efficiency of the replaced and replacing system.

Other points on the general betterment of factory conditions are: a greater accuracy on the manufactured product, decreased spoilage, less accidents, less eye strain, more order and neatness, easier supervisions, a possible 24-hr. utilization of properties if necessary and greater comfort and more cheerful surroundings for the workmen, with a consequent decreased labor turnover.

Besides, correct illumination is not an added expense and luxury. It is a sound, demonstrable method of increasing revenues by a judicious investment in lighting apparatus.

Statistics show that if the average expense of five workmen and their supervision equals $5000 annually, the total cost of illumination will be paid for if it saves but 3 min. daily of each man's time—one-half of 1 per cent of the cost of supervision and wages! There can be no stronger recommendation to the industrial plant to employ good illumination. Yet on an average, good lighting saves at least 30 min. of actual time of each man per day, besides producing the previously stated considerations.

## EFFECT ON THE EYE

THE PRESENT accepted theory of light is that it con-

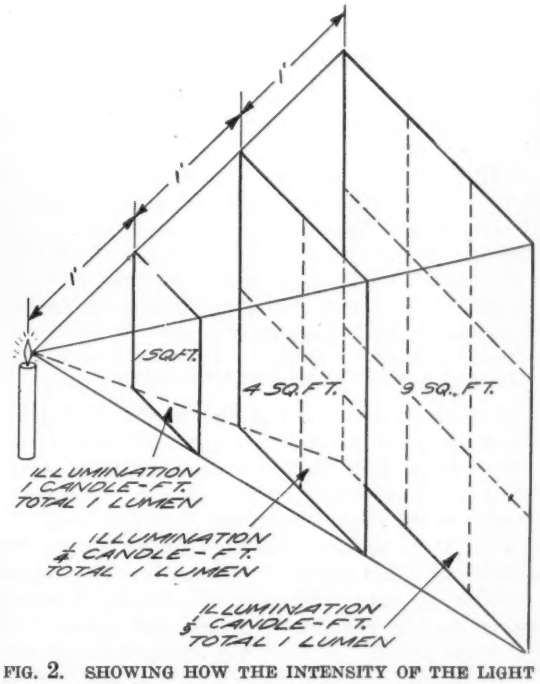



FIG. 2. SHOWING HOW THE INTENSITY OF THE LIGHT VARIES AS THE SQUARE OF THE DISTANCE

sists of vibrations in the ether, which theory says is a universal jelly-like substance pervading all space and matter. Not all ether waves appear as light, however. Some appear as heat and some as electricity, but the waves capable of affecting the optic nerve are termed "light waves." This light may be anywhere from very bright to very dim, and, in order to accommodate the retina of the eye to various intensities, a small muscular

curtain called the iris covers the front of the eye and this has a circular opening which varies in size, according to the intensity of light. If, in artificial illumination, the iris must constantly readjust itself to accommodate various intensities of illumination, due to an uneven spacing of lamps, or the use of a single drop light shining directly on the work, with the rest of the space in comparative darkness, it follows that the iris, like any other much-used muscle, will soon tire. This condition is called eye strain and, if it occurs too frequently, will result in permanent injury. The condition of the eye under correct and incorrect illumination is shown in Fig. 1. The object of scientific illumination is to prevent eye strain by a uniform and unvarying illumination, not intense, like daylight, at which the iris is closed to a minimum, but of such intensity that the eye can easily distinguish all objects without extra effort with the iris

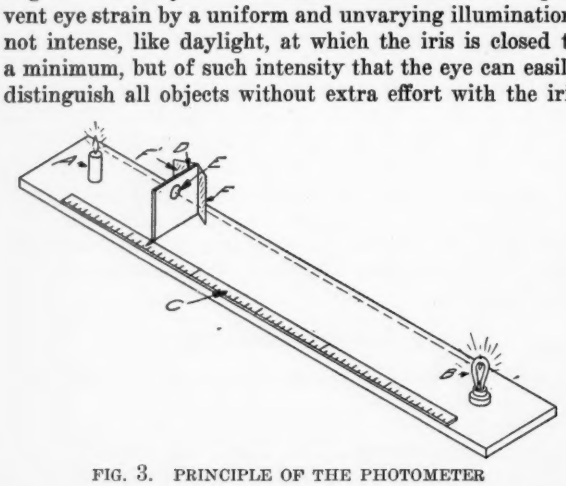



FIG. 3. PRINCIPLE OF THE PHOTOMETER

fully extended, and with such uniformity that the iris will maintain the same opening, no matter where the line of sight is directed.

With a full iris opening, it is evident that to look directly at a bright light, or even a brilliant reflection, will cause severe discomfort and, if continued, positive permanent injury. Even the reflections from shiny metal surfaces or glazed paper may hurt the eye. This is called "glare," and one of the objects of scientific illumination is the elimination of glare.

### Practical Units of Light

In order to arrive at definite results, it has been necessary to provide certain units and methods of measurement which have definite values under prescribed conditions. The total quantity of light is generally spoken of as the "flux," a popular definition being "the flux of light is the total visible radiation issuing from the source of illumination." This can best be visualized by considering light as made up of a bundle of straight lines emanating radially from a point source. The greater the number of lines, the greater the intensity.

Various units of light have been proposed and successfully used, but the commonly accepted units in America are the "candle" and the "lumen." Although the light from an ordinary candle may vary considerably, yet the term "candle" has a distinct and measurable meaning, and a unit of one "candlepower" is a very definite quantity.

As light proceeds radially from a point source, its density on a given surface varies as the square of the distance between the surface and source. For instance, if a surface is placed one foot from a source of one candle, the resulting illumination on the suface is one "candle-foot." If the surface is moved 2 ft. away, then the illumination is not ½, but is $(\frac{1}{2})^2$, or ¼ candle-foot. Three feet away, the illumination would be 1/9, etc. In the first case, if the surface were one square foot and every point one, if it were one foot distant from the point source, i. e., the surface were one square foot of a sphere 1 ft. radius, then the illumination on every point is one candle-foot, but the total illumination on this surface is one lumen. In other words, one candle-foot is equal to one lumen per square foot. This is shown diagrammatically in Fig. 2.

Another unit not so commonly used is the "lambert." This is the unit of light which is reflected from an illuminated surface and is used in special methods of calculating the luminous flux necessary in a given installation, especially where a dark product is handled, such as in a garment factory making dark clothes.

It is evident that the science of illumination resolves itself into three (or perhaps four) primary measurements. (1) The luminous intensity of a source as measured in candles or candle power. (2) The illumination of a surface as measured in foot-candles. (3) The

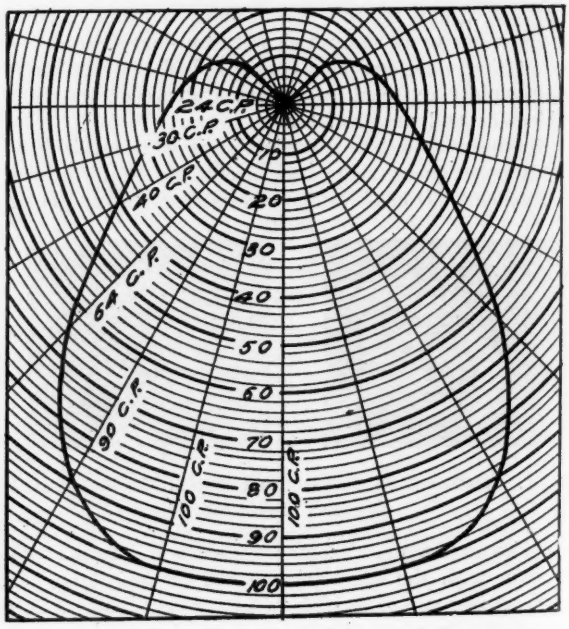



FIG. 4. HOW TO READ A PHOTOMETER CURVE

total luminous flux as measured in lumens. Sometimes (4) the reflected brightness as measured in lamberts.

### Measurement of Light

Set a lighted candle and an incandescent lamp side by side; it is impossible to tell by a direct comparison the relative intensity of each, but bearing in mind the fact that the illumination of a surface decreases as the square of the distance from the source, it is evident that there will be some point midway between the two lights upon which both sources will produce equal illumination. This suggests the principle of the photometer. Referring to Fig. 3, the candle A and the lamp B are

placed on the ends of an equally divided scale C, generally about 3 ft. long. Moving over this scale is an upright stand D, with a small circle of paraffine-soaked paper, E, in its center. By means of two obliquely placed mirrors, F and $F^1$, it is possible to observe both sides of the paper at once. The stand, D, is moved nearer to one source and farther from the other until the paper appears to be illuminated on both sides. Then the comparative candle powers are proportional to the square of the distances between sources and stand, D. For instance, if the stand showed equal illumination with a distance of 6 in. from the candle and 24 in. from the electric lamp, and if the candle is one candle power, then the equation becomes $1 : x = (6)^2 : (24)^2$ in which x is the candle power of the lamp. Solving for x gives 16 c. p.

Instead of candles, however, it is customary to use a well seasoned electric lamp which has been standardized by some reliable testing laboratory. In season-

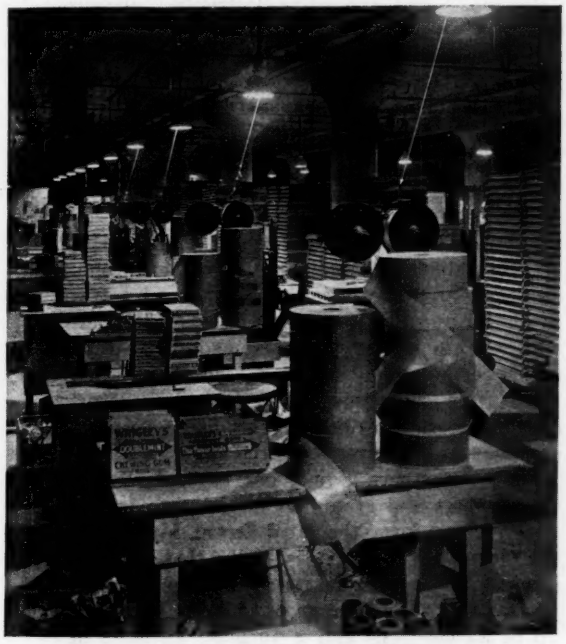


FIG. 5. A MODERN, WELL-ILLUMINATED PLANT

ing a lamp, it is customary to operate it at a higher voltage than will ever be applied during its life as a standard.

## PHOTOMETRIC CURVES

ALTHOUGH for a theoretical discussion of principles, it is necessary to consider light as emanating from a single point source, yet this is not the case in reality; but it is practical to consider an electric lamp as a point source when the distance is great (20 times or more) as compared with the diameter of the source. Due, however, to the irregular shape of the source, and the necessary physical accessories and dimensions to the light producing element, the candle power is not the same in all directions. For this reason, it is necessary to construct a curve showing the apparent candle power as viewed from different directions.

Consider the curve in Fig. 4. Assume the lamp to be at the point O, and the observer or photometer placed on the vertical line on the observation circle facing the lamp. Since the curve crosses this line at the 100-c. p. circle, it means that when viewed from this point, the lamp is apparently giving 100 c. p. Now the observer moves to the 45 deg. line and there the graph crosses at the 64-c. p. circle, indicating that at this point, the lamp gives only 64-c. p. On the 60-deg. line, it apparently gives 40 c. p., and on the 90-deg. line, it apparently gives 24 c. p. and so on. This is easily reduced to foot candles by considering the feet distance from the source along any line. For instance, a point one foot distance along the 60 deg. line will receive 40 foot candles illumination; 2 ft. distance will receive 10 foot candles; 3 ft. will receive 4.44 foot candles $(40 \div 3^2)$; and so on. If the surface which is 2 ft. away is one square foot, then it will receive an illumination of 10 foot candles or 10 lumens. If it is 2 sq. ft., it will still receive 10 foot candles per square foot, but the total quantity of light will be 20 lumens. However, it will be readily seen that as the surface increases, it cannot all fall under one line, but will partly fall under another line which has a slightly different apparent intensity in footcandles.

TABLE I. INCANDESCENT LAMP DATA

| 110-125 Volt Mazda C Lamps - Pear Shaped Bulb. | | | | |
|---|---|---|---|---|
| Watts | Watts per Spherical C.P. | Spherical C.P. | Lumens per Watt | Total Lumens |
| 75 | 1.09 | 68 | 11.5 | 865 |
| 100 | 1.00 | 100 | 12.6 | 1260 |
| 150 | .92 | 163 | 13.7 | 2055 |
| 200 | .90 | 222 | 14.0 | 2800 |
| 300 | .82 | 365 | 15.3 | 4600 |
| 400 | .82 | 487 | 15.3 | 6150 |
| 500 | .78 | 641 | 16.1 | 8050 |

To state the various intensities requires a photometric curve, but lamps are often rated by their "mean horizontal candlepower." That is, all the values in a horizontal plane are taken with the lamp in its normal operating position and the average of all values is called the "mean horizontal candlepower." For instance, a 16-c. p. lamp will give an average of 16 c. p. in a horizontal direction.

The mean spherical candle power of a lamp is an average of all the intensities in a sphere. This is seldom of value except to find the total lumens given off by a lamp. Since the calculation of illumination is usually made by the "total flux of light" or the "lumen" method, which will be fully described in a subsequent article, the lamp manufacturers generally rate their lamps as giving off a certain number of lumens at their rated voltage, or as giving a certain number of lumens per watt. The accompanying table shows the candle power and lumens of various wattage lamps. Complete tables of all lamps would comprise a small volume in themselves but are gladly furnished gratis by any large lamp manufacturer.

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IF TOP-NOTCH EFFORT yields you no happiness there's something wrong either with you or your efforts. Sit down and do some analyzing.—Forbes Magazine.

# Electricity

## Its Real Nature and How It Permeates All Matter. By Terrell Croft

ANYBODY who proposes to acquire a good working idea of how electricity acts, why it acts as it does, and how to control and utilize it, should know, in a general way, what electricity is. A knowledge of this thing is not of "high brow" theoretical interest only. Extended experience has shown that it is very important practically.

It will not take long to tell what electricity is: Electricity is the stuff of which everything is made. No endeavor will be made to show here why it is believed this is true, because it would make a pretty long—though interesting—story. Suffice it to state that it is reasonably certain this is true. Some reader may remark: "That's a funny statement, anyway; do you mean to say that this table by my side, the paper on which this printing is, the ink on the paper, the window glass over there—all of these things around me—and even I, myself, are made of electricity?" That is it precisely. Note carefully the following explanation.

Everybody has, probably, heard the term "matter." Now, the word "matter," in its scientific sense, means anything tangible—anything which has weight and occupies space. Hence, it follows that air, water, a ball bat, a fish, a cap, coal, iron, anything that can be seen or felt or which has weight—is matter. Matter is composed of minute particles which are called molecules. There are as many different kinds of molecules as there are different kinds of matter. A molecule is the smallest particle into which any certain kind of matter can be divided without its losing its characteristic properties. For instance, a molecule of table salt tastes like salt, acts like salt, in fact, has all of the general properties of a lump of salt except that it is ever, ever so much smaller. Molecules are so small that we cannot, probably, ever expect to see one, even with a microscope of the very greatest magnifying power.

In fact, a molecule of salt is about one ten-millionth of an inch

$$\left(\frac{1}{10{,}000{,}000}\text{ in.}\right)$$

in diameter—ten million of them could be placed side by side in a row between the 1- and the 2-in. division marks on a ruler.

But molecules are made up of still-more-minute particles which are called atoms. Now, while there is an almost infinite number of different kinds of molecules—different kinds of matter—there are only about 80 different kinds of atoms, which are called elements. This means that all matter is composed of 80 different kinds of primary particles. Molecules can in many cases be broken up into their constituent atoms by chemical action.

Thus, if an ounce of salt, that is of salt molecules, be, by the application of suitable methods, broken up into its constituent atoms, the result will be a lot of sodium atoms and a lot of chlorine atoms. (That is, each molecule of salt is composed of an atom of sodium—a metal—and an atom of chlorine—a gas.) And the combined weight of the sodium atoms and the chlorine atoms, thus derived from one ounce of table salt, will, so it can be shown, be exactly one ounce, which proves that table salt is composed of sodium and chlorine only.

Atoms are much smaller than molecules. It has been estimated by scientific men that an average atom is about a billionth of an inch

$$\left(\frac{1}{1{,}000{,}000{,}000}\text{ in.}\right)$$

in diameter. In other words, an average atom is about a hundred times smaller than an average molecule.

Atoms, so it is now believed are composed of electricity. Comprising each atom are negative-electricity "electrons" and a positive-electricity "nucleus." The electrons are almost inconceivably small particles, or corpuscles, of electricity. An electron is about one-trillionth of an inch

$$\left(\frac{1}{1{,}270{,}000{,}000{,}000}\text{ in.}\right)$$

in diameter. An atom is as much larger than an electron as the auditorium space of a good-sized church or theater is larger than the head of a pin. All electrons are just alike. There is, we think, only one kind of electron. So now you can understand why it was stated in one of the first paragraphs that "electricity is the stuff of which everything is made." Electrons may under certain conditions be forced to leave or be separated from the atoms. The positive nucleus—one in each atom—remains bound therein. It does not, insofar as is now known, ever leave the atom.

Although there is only one kind of electron, different numbers and groupings of electrons around a positive nucleus form the 80 different kinds of atoms of the elements. Thus, it is likely that an atom of the element hydrogen comprises only one electron and its positive nucleus; an atom of chlorine is, possibly, made up of 35 electrons and a nucleus; an atom of copper, of 65 electrons and a nucleus; and so on. On this basis, the heavier an element is, the more electrons it contains. Furthermore, the more electrons there are in an atom the bigger is its positive nucleus. The positive nucleus is always of such size that its positive electricity always (in a normal atom having its usual complement of electrons) just neutralizes the negative electricity of the constituent electrons. Hence a normal atom exhibits no external indications of electrification.

The reader should be certain that he appreciates the great difference in the sizes of electrons, atoms, and molecules. Consider this analogy: If a drop of water were magnified to 100,000 times the size of the earth, its molecules would be about 100 times the size of the earth; its atoms would be about the size of the earth; and its electrons would then be about the size of base balls.

It is then believed that each atom comprises from one to a number, the number depending on the kind of atom, of electrons. These electrons are normally interlocked

in the atom by the attractive effect of the positive nucleus. The electrons are revolving around the nucleus at inconceivably great speeds in regular circular or elliptical orbits within the atom. They are supposed to move in somewhat the same manner as that in which the eight satellites of the planet Saturn rotate in their orbits.

Now, the distinguishing property of electrons is that they tend to repel each other with enormous forces. The electrons "locked up" in atoms, however, cannot exert these great repelling forces because their repelling tendency is neutralized by the action of the positive nucleus which exists within the atom; but if an electron is by some means torn and thereby isolated from an atom, then it exerts its repelling force.

These electrons are not packed solidly in the atoms. Obviously, this could not be possible, in view of the size, as stated above, of the electron as compared with that of the atom. Lodge, the great English scientist, states that "Electrons occupy the otherwise empty region of space which we call the atom, in the same sense that a few scattered but armed soldiers can occupy a territory—occupying it by forceful activity, not by bodily bulk."

"Well," the reader inquires, "What has all this about molecules, atoms, and electrons, to do with my getting an understanding of some of the electrical actions which are occurring around me every day?" Just this: Atoms can, it is believed, when acted upon by some external agent, such as friction or electric force, be made to lose electrons or to gain electrons. Now, as explained above, an atom which contains its normal complement of electrons exhibits no unusual properties. This is because the repelling tendency of its electrons is neutralized by the positive nucleus within the atom—it is thereby a neutral atom. But if the atom loses or gains an electron, it thereby acquires, by virtue of the repelling tendency of these free electrons, a property which the books call "electrification."

If the atom gains an electron more than its normal complement, it and the chunk of matter in which the atom resides become negatively electrified or charged. If the atom loses an electron, it and the piece of matter in which it is located become positively electrified or charged. Note that when there is an excess of electrons associated with a thing, it then acquires certain remarkable properties and is said to be negatively charged or electrified. When a thing has associated with it less than the normal number of electrons, it has certain other properties and is said to be positively charged or electrified.

Also note this: An electric current—the thing that makes the electric door bells ring, the electric motors pull their loads, and the electric lamp give forth light—is a stream or flow of these electrons in the wires or conductors of the electric circuit and of the devices themselves.

There is a certain definite quantity of matter in the universe. Matter cannot be created or destroyed. Hence (since all matter is composed of negative electrons and positive nuclei, both of which are electricity particles) is there a certain definite quantity of electricity in the universe? Such is the case. It follows, then, that electricity cannot be "generated," "created," or "developed," in spite of the fact that these terms are sometimes, in error, used in this sense. We can, by utilizing batteries or dynamos in certain ways, force electricity (electrons) to move. This electricity (electrons) in motion constitutes what we call an electric current. In making the electricity move, however, no electricity has been created. Electrons, which were already in existence, have been started in motion.

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# Industrial Plant Distribution

By J. F. Adler

PANEL BOXES are now considered almost essential for the distribution of electrical energy in industrial plants. Where they are used, the installation is much simplified. The following brief description indicates how panel boxes can be effectively applied in connection with distribution systems. Two methods of distribution, shown in Figs. 1 and 2, will be briefly considered. With the ring-main method of distribution, shown at Fig. 1, the electrical conductors from the source of

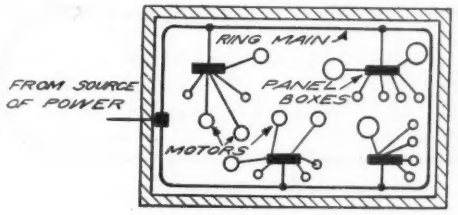


FIG. 1 RING MAIN

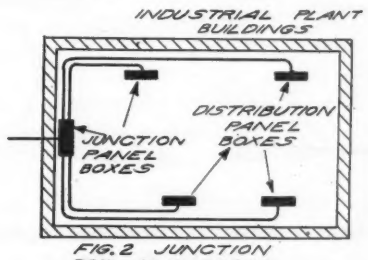


FIG. 2 JUNCTION BOX AND MAIN

FIG. 1. RING-MAIN SCHEME OF DISTRIBUTION
FIG. 2. JUNCTION-BOX-AND-MAIN SYSTEM OF DISTRIBUTION

energy are carried around the inside of the building near its walls, and usually on the roof trusses. From this main, conductors feed to the panel boxes which are installed at convenient locations in the building. Within each panel box, the branch circuits to the motors or lights connect to bus-bars, which are in reality extensions of the conductors from the source of power. Inserted, in the line from these bus-bars to each motor, there must be a fusible cut-out, and is, in addition, usually, a switch. Figure 2 shows the junction-box-and-main method of distribution, which performs the same functions as the ring-main method, but offers a somewhat greater flexibility of control. For the average industrial-plant conditions, it is likely that the ring-main method is most desirable.

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Don't waste time at the shrine of an oracle. No oracle ever said anything new. The secret of success was given to the world by the first successful man.

# Wear of Projecting Fibers on Belts

By W. F. Schaphorst

HERE is an argument tending to prove that the smooth or hair side of a belt should be run in contact with only one pulley of a given drive, and the rough or flesh side of the same belt should come in contact with the other pulley. By so doing creep will always be in the same direction, the projecting fibers will always be smoothed down in the same direction, and as a result there should be less wear. To do this, belts cannot be operated in the usual fashion. A "twist" must be made in the belt as indicated in Fig. 2.

Belt manufacturers and users will agree that a piece of leather or other fibrous material can be worn down more quickly by rubbing "back and forth" than by constantly rubbing in the same direction. When a carpenter sandpapers a piece of wood, he rubs the paper "back and forth" over the wood in every direction because he finds the wood will smooth down better and

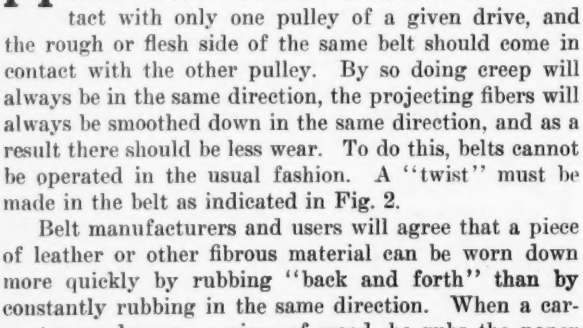



FIG. 1

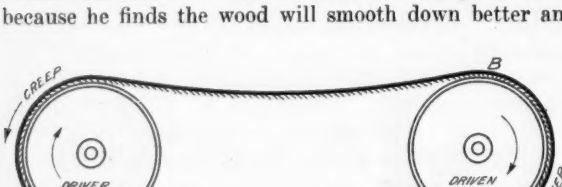


FIG. 2

FIG. 1. SHOWING HOW THE FIBERS REVERSE THEIR POSITION AT EACH PULLEY

FIG. 2. BELT TWISTED SO THAT ONE PULLEY BEARS ON HAIR SIDE, THE OTHER ON FLESH SIDE

more quickly in that way. Pull a sack of rags, say, over a patch of grass constantly in the same direction and count the number of passes necessary to wear off the grass. Then repeat the experiment on a similar patch of grass except that the dragging will be "back and forth" over the same path. Doesn't it stand to reason that the grass in the second experiment will be "irritated" more and will wear off sooner?

Belts as ordinarily placed on pulleys are subject to this "back and forth" rubbing because of the well known fact that all belts creep. The writer has never seen this point covered in print, and since there are many thousands of belts in daily use all over the country, it is a matter that seems well worth discussing. If the life of a belt can be lengthened by giving the belt a twist as indicated in Fig. 2, and for the reasons given above, the belt should by all means be twisted if the conditions of the drive are such that it can be done without impairing transmission.

Figure 1 shows a belt with the projecting fibers exaggerated. Space is left between the pulleys and the belt for the purpose of showing distinctly how the fibers behave when coming into and out of contact with the pulleys and while in actual contact. Belts always creep toward the tight side. They must creep that way. There is nothing else for them to do so long as they possess elasticity. All belts, even steel, are elastic. That being the case, let us trace the action of the projecting fibers of the belt in Fig. 1. As the belt comes into contact with the driver pulley shown at the left the fibers are leaning over toward the right, because that is the way they were "rubbed" by the driven pulley which they just left. Immediately upon touching the driver pulley, though, the fibers find that the belt is creeping toward the tight side in opposition to the direction of rotation of the driver pulley. At the point marked "A," therefore, a turning point occurs and soon thereafter the fibers are smoothed over in a direction opposite to that in which they approach the driver pulley.

The fibers now rush over to the driven pulley with an antagonistic slope as shown on the top side of the drive. Upon touching the driven pulley, though, these fibers find that the belt is traveling faster than the driven pulley because creep is again toward the tight side, and at the point marked "B" we have another turning point where the fibers are combed, bent, or rubbed back to the original position. Then the fibers dash over to the driver pulley once more and they are again reversed, and so on. Every time a projecting fiber comes in contact with a pulley in drives of this kind it is reversed in direction. This occurs revolution after revolution, day after day, year after year, and there is, therefore, little wonder that unless a belt is properly cared for it will wear out quickly.

No doubt there are ways in which this wear can be largely prevented. It is evident that if the belt is "bone dry" the wear is bound to be more rapid than if it is lubricated for the same reason that metallic rubbing surfaces must be lubricated if wear is to be reduced to the minimum. Lubricant fills up the "rough spots" in the metal, thus allowing the "bumps" to pass over one another.

In the case of a lubricated belt the action may be somewhat different. The lubricant will probably not fill up the entire space sufficiently to prevent the projecting fibers from coming in contact with the pulleys, but the fibers will be so lubricated that they will bend back and forth more easily and without appreciable or serious wear.

No doubt there are several solutions to this problem. For mechanical reasons it is often undesirable to give such a twist to a belt as shown in Fig. 2. Perhaps it can be avoided by applying a wearing face to the belt and operating in the usual way. The writer, however, does not know of any practical wearing face aside from stick preparations, and they often do more harm than good along the line of excessive power consumption. It may be, also, that the reversal of direction of projecting fibers has much to do with the pulling power of a belt. In the opinion of the writer a greater pulling power can be obtained with a belt in which the fibers do not reverse, because contact can be made more intimate. That, however, must be left to experiments and experience, on which reports may be made later. The subject has at least been broached, and is left with the reader to do with it and think of it as he will.

# The Adventures of Murdock

YOUNG ENGINEER OFFICER'S QUICK THINKING SAVES AMERICAN SHIP FROM SUBMARINE ATTACK. BY A. W. KRAMER

THE U. S. S. Western Star, 5000-ton cargo liner of the Emergency Fleet Corporation, purred her way gently across the smooth waters of the North Atlantic, on a sunny afternoon in September, 1918. Lieutenant Robert Murdock, first assistant engineer, leaned idly over the rail as he remarked to the chief engineer who stood beside him, "Here comes Cox from the wardroom, chief—seems to be feeling much better now that the weather has calmed down. He has been seasick ever since we left New York."

"Yes," laughed the chief, "this is his first trip and he has not found himself to be very seaworthy. He isn't much of a sailor and doesn't seem to know one end of the ship from the other. This morning he wanted to know what made the ship go, and when I told him, the propeller, he asked me whether the propeller was located in the engine room."

Murdock laughed. Mr. Cox, the paymaster, furnished much amusement for the "old salts" aboard. He was a pleasant chap of about twenty-five, and while he was an expert accountant and in every way qualified to perform the duties of paymaster, he had evidently never been aboard ship before. His apparent innocence and entire ignorance of ships and ship terms was amazing.

"How are you feeling now, Pay?" inquired the chief laughingly as the paymaster joined them.

"Pretty good, chief. It's not such a bad life after all, is it? The ocean is remarkably smooth today and I haven't been sick at all."

"Of course it isn't," replied the chief, "you've got to become accustomed to it. You will be a sailor yet, if you stick to it. Have you had supper?"

"Yes, I've just finished—the first good meal I have had since coming aboard. I was just taking a walk around the deck and watching the sun set—the sky is pretty, isn't it?"

"We have been admiring it also," said Murdock, "this is certainly beautiful weather. Too calm to suit me, though—submarines are more active in weather such as this, and we are getting pretty well into the danger zone now. I imagine we are only about a thousand miles from France."

"Submarines," repeated the paymaster anxiously, "Do you think we will see any?"

"Well, I hope not," said Murdock, "but we can always expect them when we get over this far. Last trip they got one of the ships in our convoy."

This bit of information by no means pleased the young paymaster and for a moment he anxiously scanned the horizon as though in search of a U-boat. Only for a moment, however, and then the worried expression left his face. "Well," he remarked, "I guess I can do my part if one should hit us, but I'm not going to worry about them. By the way, why is all that water coming out of the ship?"

Looking out over the rail the two engineers saw that the water which the paymaster referred to was nothing more than the condenser discharge from the circulating pump. This was discharged from the side of the ship and formed a stream about a foot in diameter. Perceiving an opportunity for a bit of fun at the paymaster's expense, Murdock replied, "Oh, that is the bilge water we are pumping out. You see, this old ship leaks quite badly and we have to keep the pumps running day and night to keep her afloat."

"What!" exclaimed Cox, "does she leak as bad as that? If I had known that I wouldn't have come aboard. It must be pretty dangerous to——"

"No," interrupted the chief as he winked at Murdock, "there is no real danger as long as we can manage to keep the pumps going. Of course if they should ever break down, there wouldn't be much chance for us. You see how much depends upon the engineers? We not only run the ship, but we also keep it afloat. Have you ever been down in the engine room, Pay?"

"Not yet, chief," said the paymaster, "I have looked down there a number of times as I passed by, but it was too hot down there for me. However, I am coming down sometime to take a look at the place—I want to see what the turbine looks like; I have heard you fellows talk so much about it, I'm curious."

"Come down tonight, Cox," suggested Murdock, "I'll be down there about eight o'clock and will be able to show you around."

"Good idea, Murdock, I'll do that," he replied. "But I must go now; I've got some work to finish up in the office. I'll see you later."

After the paymaster had left, Murdock and the chief engineer laughed heartily. "He sure takes the prize," said Murdock, "He actually believed my story about the pump."

"I wonder if he did," mused the chief, "sometimes I think he knows more about the subject than his manner would seem to indicate. He is too innocent to suit me. A man with his education should have more intelligence regarding mechanical subjects."

"Yes," replied Murdock thoughtfully, "it would seem so, yet once in a while one meets a person who never even thinks of investigating the mechanical features of a machine, who rides in an automobile or a street car, and is surrounded on all sides by electrical and mechanical contrivances, yet has no idea as to their operation and apparently does not care to know. He takes everything for granted."

* * * * * * * *

Eight o'clock found Murdock below in the engine room for his nightly round of inspection. The first engineer did not stand a watch, but was responsible for the successful operation of all the machinery, consequently gave it frequent and close attention.

Ensign McKenzie, the officer on watch, greeted Murdock cheerfully as the latter made his appearance. "We are making fine speed tonight, Mr. Murdock," he said. "The average revolutions for the past four hours is 71. That is more than she has ever made since I have been aboard."

"That's fine, keep up the good work," replied Mur-

dock encouragingly. "At this rate, we should reach port in four or five days. What steam pressure are you carrying?"

"Two hundred pounds even, sir," reported the watch officer. "I cut it down from two hundred and five on account of excessive vibration of the turbine. She seems to run more smoothly at two hundred."

Murdock carried out his inspection with great care. Not a pipe, not a valve in the maze of complicated machinery escaped his expert eyes. Oil and steam pressures were carefully noted; temperatures of various bearings observed and the turbine itself tested for undue vibration or noise. Finally, satisfied that everything was running smoothly, he made his way back to the log desk where he talked with McKenzie until the paymaster came down. He had warned McKenzie beforehand and had told him of the conversation up on deck with the chief that afternoon.

"Hello, fellows," said the paymaster a few minutes later as he stumbled down the engine room stairs. "Here I am. I nearly broke my neck, though, getting down those fool stairs of yours. Good Lord, it's hot down here! How do you fellows stand it?"

The two engineers laughed.

"Why, this is not hot; it's cool down here tonight, Cox," said Murdock. "It's only 98 deg. at the log desk; sometimes it goes as high as 115 or 120 deg."

"Well, it may be cool for you fellows but it's too hot for me. Where is the turbine?" he inquired, foolishly looking all around but never glancing at the roaring, driving turbine directly before him.

"Oh, we keep that back in the shaft alley," explained the first assistant. "It's too hot for that in here. We have to keep it cool."

McKenzie turned away to conceal his laughter, but the paymaster's face remained unchanged. He was evidently fully satisfied with Murdock's absurd explanation, and did not question it. Other things caught his eye and his absolute ignorance amused the two engineers as they led him around.

"And what is this big thing?" he asked presently when they returned to the turbine.

"This machine," explained Murdock, laying his hand on the turbine casing, "is the big centrifugal pump I told you about this afternoon. It pumps the water from the bilges and discharges it overboard."

"And what are those little clocks for?" he inquired a little later as they stood before the panel on which the various pressure and vacuum gages were mounted.

"Those are the distance meters," said McKenzie; "by multiplying one by the other, we obtain the number of miles we travel per hour.

"I see," said Cox, understandingly; "it is the same as a speedometer on an automobile, I suppose."

"Exactly," grinned Murdock. "Now, if you wish, Cox, I will take you up to the dynamo room, and then you will have seen everything. With all the knowledge you are assimilating tonight, you should soon be able to take out an engineer's license."

"No, I don't think I will," was the reply. "It's too hot down here for comfort. I guess I'll stick to the pay office."

"Did you fill him with any more nonsense while you were up in the dynamo room, sir?" asked McKenzie ten minutes later when Murdock returned.

"No, I thought I had told him sufficient down here, and he did not seem to be particularly interested in the electrical apparatus. He soon went above."

"By the way," continued Murdock, "I noticed you were running No. 1 dynamo. You had better cut it off and run the small generator tonight. The wireless has been ordered not to do any transmitting on account of being in the danger zone, so the load will be light."

"Very well, sir," answered McKenzie. "I'll change them over immediately. Any other orders, sir?"

"No, that will be all," replied the first assistant as he turned to go above. "Guess I will turn in. Good night."

Murdock went directly to his stateroom, where, after reading for an hour, he went to bed and was soon fast asleep.

Shortly before midnight, he was awakened by an impatient knocking on his door and upon opening it, he found an oiler with a message from McKenzie, asking him to come down to the engine room at once.

"Tell him I will be right down," he ordered. "What is the trouble, do you know?"

"Yes sir," answered the man, "something is wrong with the steering engine. Mr. McKenzie wants to know if you will come back there."

Making his way through the darkness across the after cargo deck to the stern end of the vessel, Murdock found McKenzie and the oiler examining the disabled steering engine. This was an intricate machine driven by two powerful reciprocating engines, for the purpose of operating the ship's rudder, to which it was directly connected. It was located under the poop deck and was controlled from the bridge by the telemotor.

The nature of the accident was at once evident to Murdock as he entered the compartment. One of the cylinder heads had been blown off.

"She's blown clean off, Mr. Murdock," said McKenzie as he made room for his superior. "I did not know of the trouble until the bridge notified me that the rudder did not respond and ordered me to close down the turbine. When I got here, the room was so filled with steam that I could not enter until I had cut off this steam line. In the meantime, I sent for you."

Murdock examined the broken engine closely. The cylinder head which had been blown against the after bulkhead was cracked in such a way as to render it useless for further service. Three of the studs which had held the cylinder head in place were stripped, although the threads on the remaining three were uninjured. This puzzled Murdock. He could not understand why all of the studs had not been stripped.

"Bad business, McKenzie," he said. "There are no spare cylinder heads for this engine aboard and we certainly cannot run without it. I guess we will have to make a temporary head from a piece of floor plate. Send Perkins to call out the repair gang, while I see the chief."

"Yes, sir," said McKenzie as he started to comply. "Shall I have these broken studs removed? We will have to make new ones."

"Yes," replied Murdock; but almost instantly, he

countermanded the order. He was curious about those studs and wanted to examine them more carefully. "We will wait until the chief has seen them," he explained to McKenzie. "Ah, here he is now."

The chief engineer needed no explanation, for by this time the whole ship was astir, and he was already aware of what had occurred.

"How did it happen, Murdock?" questioned the chief. "Let's take a look at it."

Together, they examined the wrecked cylinder.

"Curious, how these three bolts are stripped and not the others, chief," remarked Murdock.

"The nuts must have loosened and worked off, due to vibration," explained the chief, "and then, the remaining bolts were not strong enough to hold the head in place against the steam pressure.

"Of course, that's possible," agreed Murdock, "I had thought of that, but it seems rather a remote possibility. Some one should have noticed the fact that the bolts were loose before they dropped off."

"Well, we can investigate the cause of the accident later," said the chief, "let's get these broken studs out, and have new ones made. First, however, Murdock, I wish you would go down to the dynamo room and bring up that portable lamp we have there—it's too dark here to work without it."

Murdock hastened down to the dynamo room and soon found the portable extension lamp which the chief had referred to. In removing the cord from the hook on which it was coiled, however, the lamp slipped out of his hand and fell upon the steel deck. The heavy wire guard which protected the bulb prevented it from being broken but thinking that perhaps the filament had been injured, he stepped across the room to the ship's switchboard to test it out. To his satisfaction, he found that it was intact and was in the act of unscrewing the plug, when, to his surprise, he noticed that the pointer of the switchboard ammeter fluctuated violently.

"That's queer," he thought, "the load on the generator at this time of the night should be steady unless the wireless is in operation. But the wireless was ordered not to operate tonight. Perhaps the order has been countermanded."

At any rate, he resolved to find out, for if the radio transmitter was in operation, he would have to cut in the large dynamo.

But the wireless was not in use! "Indeed, no!" the operator told Murdock when he inquired. "We haven't used the transmitter at all tonight and just a half hour ago, our receiving apparatus failed to operate. I was copying the time signals from Paris when suddenly the signals faded away and reception ceased. The trouble apparently is in the aerial system. My assistant is out examining it now."

"Are you certain, you were not using your motor-generator for testing purposes about five minutes ago?" again inquired Murdock.

"Absolutely certain, Mr. Murdock," replied the radio operator. "Why?"

"Come with me," said Murdock ignoring the operator's question. "I'll show you something. Take a pencil and some paper with you."

The pointer of the ammeter was still oscillating when Murdock returned to the dynamo room with the operator.

"Watch this ammeter," ordered Murdock. "See whether you can make anything out of the movements of the pointer. Looks like code to me."

"Why, certainly," exclaimed the operator after half a minute's observation, I can read the letters, but they have no meaning. They are those of the International Morse code.

"Copy them," said Murdock, somewhat excited. At the same time he began to test the various feeder switches from which current was distributed to different portions of the ship, by rapidly opening and closing them. None of his tests had any effect upon the ammeter until he opened the switch designated "Starboard Staterooms." This proved effective. The pointer immediately came to rest, thus indicating that the disturbance was on the circuit which served the three starboard rooms; namely, the chief's, Murdock's and the paymaster's.

"That's the one," he exclaimed, quickly closing the switch again. "You remain here," he added, as he turned to go, "and copy all you can. Can you read anything of the message you have taken down?"

"No," replied the radio expert. "I can't read it, but it seems to be German. The four dashes which is the German signal for C H occurs quite often."

Outside the paymaster's room, five minutes later, Murdock, the executive officer and the chief engineer listened carefully.

Faintly, almost imperceptibly, the smooth high-pitched hum of a radio transmitter could be heard.

"This is the room," whispered the executive officer. "Have your guns ready, men. Take care not to stand in front of the door," he warned as he knocked sharply on the panel.

The noise of the radio apparatus immediately ceased, and for a few minutes nothing was heard.

A good second knock brought no response and the executive officer then gave the command to open the door.

"Just a moment," came the half sleepy voice of the paymaster. "What do you want?"

"Open this door immediately," ordered the executive officer.

The bolt on the inside of the door was drawn back noisily. Instantly the executive officer started forward to open it, but had hardly placed his hand on the door knob when the silence was broken by the sharp crack of a revolver. The bullet crashed through the door, nipped the executive officer's left shoulder and flattened itself out against the steel bulkhead across the companionway. He jumped to one side. None too soon, however, for two more bullets shattered the panel in rapid succession.

"So, that's your game, eh?" cried the executive officer. "Well, we can play at that too. At him, men, through the door!"

For a short half minute the battle raged furiously. The three men in the companionway emptied their revolvers through the door as bullet after bullet crashed from the inside. Both sides fired at chance.

It could not continue, however, for the man in the room was outnumbered three to one, and presently, as the chief and the executive officer fired their last shots, a muffled cry was heard and a body fell heavily against the bullet-riddled door.

"I guess we've got him, chief," said the wounded officer. Open the door."

Inside, they found the paymaster, face down, upon the floor with two bullets through his chest, still clutching his heavy automatic. He was still alive, but died a few minutes later without regaining consciousness.

On his desk was found a wonderfully compact radio transmitting set, the whole of which fitted into an ordinary suitcase. It was equipped with a remarkably powerful vacuum tube, high-frequency generator and, as the radio operator said later, was capable of transmitting signals over 200 mi. The aerial, as it was found the next day, consisted of a fine phosphor-bronze wire strung along the edge of the boat deck. This was led through a small hole in the steel bulkhead into the room, and was practically unnoticeable.

The room was littered with charts and papers showing the course of the convoy, data regarding the cargoes carried by the various ships and other information valuable to the enemy. From the papers on the deck it was discovered that after wrecking the steering engine, he had grounded the ship's aerial by connecting the "lead-in" to the steel bulkhead through which it entered the radio-room. With the ship's radio receiving set out of commission, he could use his own transmitter without fear of detection, and had evidently been giving the ship's position to the German submarines in the vicinity. The disabled ship, of course, having dropped behind in the convoy, would have furnished an easy mark for a torpedo.

* * * *

"You see, Murdock, said the chief engineer, the next afternoon as they sat in the latter's office, "I thought he knew more about ships than he cared to make known. He displayed too much ignorance to suit me. We learned from the papers that were found in his room that he was a graduate in mechanical engineering from one of our eastern universities. He probably knew more about machinery than we do."

"Yes," admitted Murdock, "he was clever, but not clever enough. He should have put the ammeter out of order before starting his radio set. As it was, I never suspected anything until the operator told me that the radio apparatus was not working. Then I put two and two together."

"And it made four," laughed the chief.

"It always does," responded Murdock.

# Theory and Practice of Lubrication*

THE GERM PROCESS. BY HENRY M. WELLS AND JAMES ED. SOUTHCOMBE

IN THE early days of the mineral lubricating oil industry, it was considered that the perfection of lubrication lay with the production of the purest possible hydrocarbon oils, and it is a monument to the skill and efficiency of oil producers and refiners that this search for better lubricants and more scientific methods of refining has resulted in placing upon the market an enormous range of highly purified lubricating oils of every conceivable viscosity, gravity and color. This has certainly materially conduced to lubricating efficiency and has been instrumental in assisting forward to the greatest possible degree the development of engineering design. Nevertheless, we find that, for many purposes, particularly those cases requiring lubrication of bearings, etc., carrying heavy loads at relatively slow speeds, these pure mineral oils have not been ideally successful; and the need for adding to mineral oils, animal and vegetable oils to increase their "slipperiness," has been forced upon users in all countries.

It is to this peculiar friction-reducing property, possessed by many animal and vegetable and compounded oils, that the term "oiliness" has been applied to express that remarkable ability to maintain efficient lubrication under conditions of high load and slow speed, which cannot be accounted for by viscosity alone, and Professor Boys, an English physicist, has crystallized the position very happily in the following terms. Speaking in the presidential address to the Physical Society in 1908, he said: "It was found that the lubricating property of oil depended upon something which at present is unknown—it is not viscosity—animal and vegetable oils lubricate better, that is to say, they are more slippery than mineral oils of the same viscosity and, although the oil trade has known how to make good slippery mixtures, no one at present knows what oiliness is, and this is, at the present time, an important physical quest of the engineer." For this reason, there has grown up with the development of mineral oils, an extensive industry for the production of fatty oils to be used in compounding with hydrocarbons. Here, again, the demand for greater purity and freedom from acidity of glycerides has been insistent and has caused the marketing of expensive acidless tallow oils, acidless lard oils, etc. It is our object to show that such highly refined oils are not only unnecessary, but are positively ineffectual in securing the highest possible degree of friction-reducing efficiency.

At the commencement of our researches it was our object to elucidate the reason for the superiority of the fatty and compounded oils as friction reducers, and to this end we carefully collated and studied all the possible physical properties of the liquid which could influence its character as a lubricant. These properties are specific gravity, viscosity, capillarity or surface tension, compressibility and tensile strength. The other commonly determined physical factors, such as flash-point, volatility and fire-test, important as they may be in the choice of an oil, do not, of course, materially influence the frictional properties.

Statistical examination of each of these groups of physical constants shows that you can have a large number of mineral oils possesing identical specific gravity to fixed oils, but behaving differently as lubricants, and this satisfied us that gravity played no deciding part. Viscosity is, of course, of primary significance under conditions of high speed and copious oil supply,

*From a paper read before the National Petroleum Association.

but, as mentioned before, it does not constitute a criterion under the special conditions where compounded oils are found advantageous. We likewise satisfied ourselves that compressibility and tensile strength had no dominating significance, but we were forced to the conclusion that the only property which was of importance, and which had previously not been adequately studied, was capillarity, or surface tension.

Consider the case of two eccentric glass surfaces which are being forced together with a drop of oil or mercury between them. Now, since the mercury does not wet or spread over the glass, the meniscus in this case will be convex to the liquid, while in the case of oil, which wets the surface, the meniscus will be concave. In the first case, the tendency on capillary grounds will be for the liquid to gather itself up into a drop and to pull the liquid film away from the narrower constricted area of greater pressure. In the case of oil, the opposite will be the effect. The oil, owing to its meniscus, will tend to force itself into the narrow space. This is exactly what is required in a lubricant; namely, that it shall penetrate into the narrow spaces between journal and bearing and, from the foregoing considerations, one clearly sees that liquids which do not wet solid surfaces cannot be described as lubricants. Only the liquids which wet the solid surfaces possess lubricating power in the generally accepted sense.

This confirmed us that a measure of the surface tension would shed considerable light on the problem, and to this end we now devoted our attention. The usual surface tension measurement is that of oil against air, and we confirmed the opinions of previous investigators that the results so obtained shed no light at all on the question under consideration. The interfacial tension between the solid metal and oil, unfortunately, cannot be measured. But there remains yet one other means of getting information on this subject; namely, the interfacial tensions between oil and another liquid. We proceeded to measure the interfacial tension between various types of oils against water, and, lastly, against the liquid metal, mercury. The results obtained were startling in the extreme. The experimental data are published in the Journal of the Society of Chemical Industry and we propose here only to summarize the results of the investigation.

It was found that the interfacial tension against water, and also against mercury, of the fatty oils and compounded oils was much lower than was the case with any mineral oil. After a great amount of investigation, we definitely proved that this difference was due to the presence in the fatty, or compounded, lubricants of small quantities of free, fatty acids, which are absent in the great majority of mineral oils. This was a most surprising result, since it indicated that the virtue of fatty oils arose simply from the fatty acids which they contained, as impurities. We then went a step further, in that we artificially prepared oils consisting of 99 per cent mineral oil with only 1 per cent of free fatty acid. These oils gave a low surface tension. On the other hand, we removed the fatty acid from fatty oils and found that the pure fatty oils gave a high surface tension. We drew the deduction, therefore, that the friction-reducing properties were due solely to the fatty acid content and that it should be possible to obtain the desired result by adding minute quantities of fatty acids to mineral oils.

It should be remembered that all the commercially occurring fixed oils contained notable quantities of free fatty acids and even if such acids have been removed by careful attention to the refining, hydrolysis soon sets in and free acids are formed which, in even relatively minute quantities, suffice to lower the surface tension. The possibility of corrosion arising from the presence of these fatty acids we have shown to be negligible, and, in fact, to be much less likely than when using compounded oils, because, in our case, we had only minute quantities, to the order of about 1 per cent, which minute quantities are controllable and can never increase; whereas, when one uses several per cent of fatty glycerides, it is possible by hydrolysis to obtain large quantities of free acids.

The broad set of tests and results, from four machines, were these: The oils used by way of illustration were a pure mineral oil, the same mineral oil plus ½ per cent commercial fatty acids, and the same mineral oil plus 1 per cent and 2 per cent fatty acids. These were tried out against rape oil containing 2.4 per cent of free fatty acids and neutral rape oil from which the fatty acids had been completely removed in the laboratory. In every case, on each machine, the frictional resistance, when 1 per cent of fatty acids was used, was reduced by 20 to 26 per cent and to achieve this reduction by the use of pure neutral rape oil it was necessary to employ as much as 60 per cent. Further experiments made with olive oil show that the addition of 2 per cent of commercial fatty acids lowers the friction 30 per cent below that of a mixture containing 40 per cent mineral and 60 per cent olive. To put the matter in a nutshell, the frictional resistance shown by any mineral oil can be most definitely reduced by the addition of about 1 per cent of commercial fatty acids.

This is in complete conformity with the latest views of pure science.

All recent work points to the fact that it is the chemically reactive and unsaturated constituents of lubricants which promote "oiliness" and that they do so by forming new "composite" films on the surfaces lubricated with lower surface energy and opposing less resistance to shear.

The great activity of organic acids is quite in accordance with this theory.

We have hitherto confined our remarks to the effects of acids on the friction-reducing properties of oils, but there is another aspect of the matter of utmost importance. In practical use, in the power house or factory, lubricating oils are not used under ideal conditions, and, in many cases, they become admixed, either accidentally or deliberately, with water. In some cases, it is necessary that when the oil comes in contact with water, it shall mix with the water, or emulsify, as we say. Such cases are, of course, the bearings of marine engines and the guides and rods of locomotives, etc. In other cases, it is essential that the oil shall not mix or shall separate readily from the water.

We found, also, that it is possible to choose suitable acids which will confer upon the mineral oils these particular and valuable properties. By the addition to the

mineral oil of one class of fatty acids, we induce a tendency to demulsify, while other groups of acids have a powerful emulsifying influence. We are, therefore, enabled to change the character of the mineral oil, not only in relation to its properties as a reducer of friction, but also to decide its behavior under any given set of circumstances in which it may be employed.

The conclusions reached, after exhaustive research, are, briefly:

That 1 per cent of free fatty acid will lower the frictional co-efficient of a pure mineral oil by 26 per cent.

That, although such "germ process" oils are only fractionally dearer than pure mineral oil, their value as lubricants is the same as, or better, than that of heavily compounded oils or straight fatty oils.

That a logical reason has been given for the superior oiliness of compounded oils over mineral oils; namely, that the fatty acid present, as impurity, lowers the frictional co-efficient.

That there is no more danger of corrosion when using germ process oils containing limited amounts of fatty acids than when using compounded oils, and in many cases the danger is much less.

In a word, these new facts may be summarized by saying that it is now possible to combine the oiliness of fatty oils with the cheapness of mineral oils.

# Power Plant Troubles

PRACTICAL METHODS USED IN OVERCOMING DIFFICULTIES. BY H. A. JAHNKE

WE ARE frequently up against a pipe fitting job where it is impossible to make all joints meet square. This may be due to some miscalculation made in the line or apparatus, or to some unavoidable cause.

Some time ago, it was necessary to make repairs in our boiler feed line. After the repairs were completed and we were ready to replace the compound feeder, we found that the union in the lower connection would not meet square, due to the fact that the piece of pipe between the two tees was too long. As there was no time to disconnect all pipes again, and as the joint could not be made to meet square, no matter what type of ells and length of nipples were used, in order to get out of the difficulty, the nipple A was bent as shown, exaggerated, in Fig. 1.

## REMEDY FOR LEAKY COMPOUND FEEDER JOINTS

A BOILER COMPOUND feeder of the type shown in Fig. 2 leaked at joints A and B, and the engineer complained that he could not make the joints hold, no matter what kind of packing was used or how tight the bolts were drawn up. A short time after placing new gaskets, the joints would leak as badly as ever. In looking the thing over, I found that the threads on the bolts holding the joints were too short. This did not allow the joints to be drawn up sufficiently to compress the gaskets so they would hold. The gaskets would hold for a while when new, because the gasket became hot and expanded, making a tight joint for a time, but when the gasket got hard it would not expand and the joints would break.

The remedy here was either to use shorter bolts or cut longer threads on the old bolts, or to place washers over the bolts, making it possible to draw the joints up tighter. Washers were used in this case.

Some time ago, I had an experience with a high-speed engine which had just come under my charge. I noticed that the engine belt was getting soaked with oil, which, of course, made the belt slip badly at times. I found that the oil came out of the bearing next to the belt pulley, then crept along the shaft into the pulley and onto the belt.

I got busy at the first opportunity, trying to find out why the oil leaked out of the bearing. The first thing I noticed was that the bearing cap had a little lost motion, which, in turn, would allow a little oil to be splashed out of the bearing at each revolution. This oil would fall onto the shaft, then work into the pulley and onto the belt. When the bearing cap was adjusted no more oil leaked out of the bearing.

In still another instance, a small center-crank, high-speed engine direct connected to a generator leaked oil out of the bearing next to the generator and there was danger of getting the armature oil-soaked. It seemed as if there was no remedy for the trouble; the bearing was taken apart a number of times, but nothing was found that could possibly cause the trouble. The type of engine bearing is shown in Fig. 3. One day I noticed that a little stream of oil came out of the bearing at each revolution at the point A, where there was an opening next to the shaft and bearing cap. This trouble could have been remedied by adjusting the bearing cap, but, the shaft and bearing being considerably worn, it was impossible to do so on account of heating. The trouble was remedied temporarily by closing up the opening in the bearing cap with a piece of felt, as shown at A, Fig. 3, and holding this in place with a piece of wire bent around the bearing cap bolts and shaped in such a way as to bring it over the felt to hold it in place.

## KEEPING OIL FROM THE ENGINE ROOM FLOOR

A CORLISS engine, connected to a line shaft by a belt, was speeded up several revolutions per minute. After this the collar on the crankshaft, next to the main bearing, threw oil over the floor, making it necessary to use pans for catching the oil. To do away with this plan, I made an oil guard and placed it next to the eccentric, as shown in Fig. 4, at A. Four holes were drilled in the engine frame and tapped for ¼-in. screws. A piece of heavy sheet iron was then bent to an angle, as shown at B. Holes were drilled for screws to pass through, then a strip of sheet packing was placed between the guard and engine frame and fastened down with the screws. This caught the oil so it ran into the regular oil drip pan under the eccentric.

A few years ago, I inspected a plant which had been idle for some time. I found most of the equipment in bad condition, due to the carelessness of the former engineer in charge of the plant.

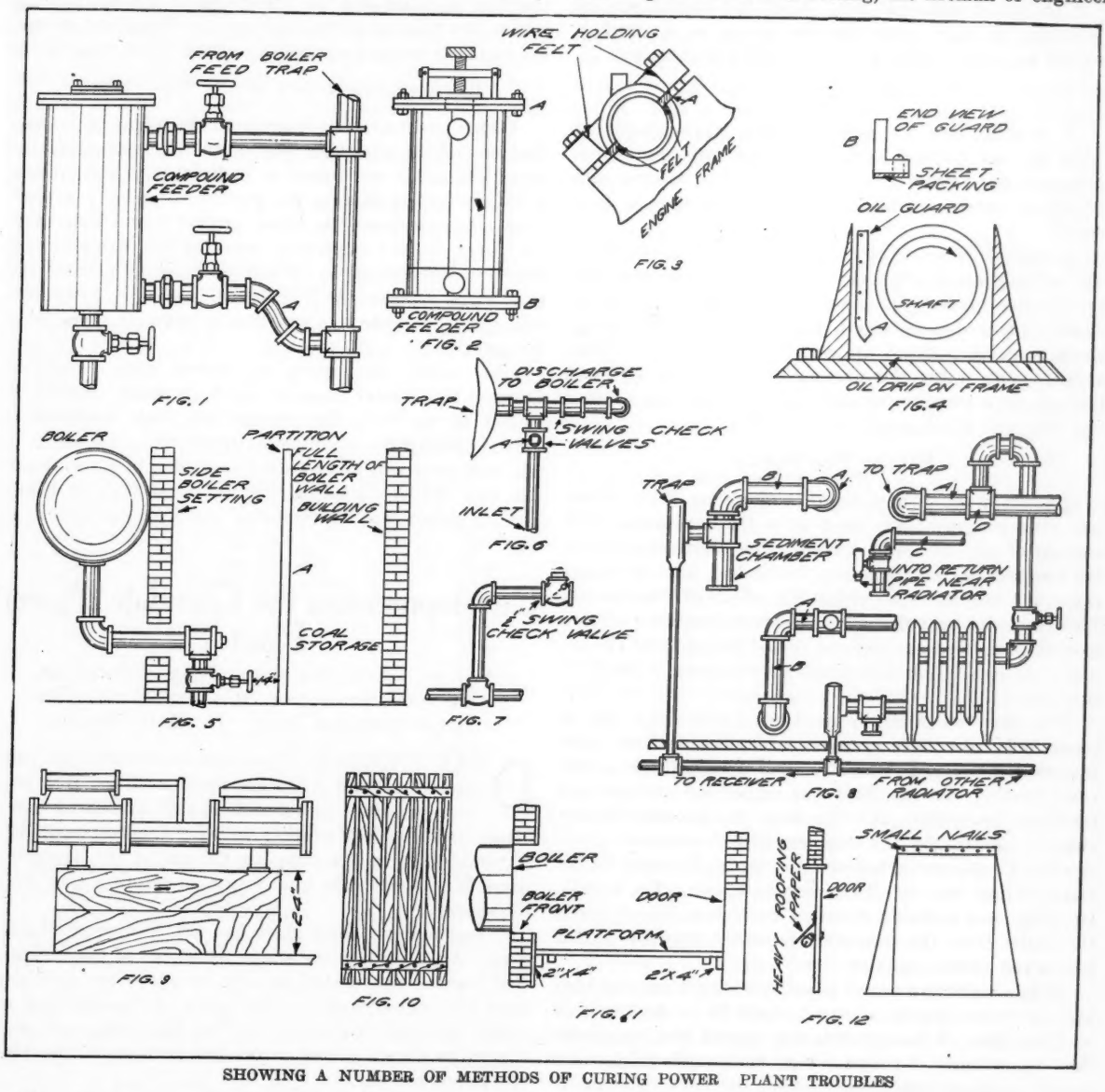
The plant consisted of a large tandem-compound Corliss engine, and a small, vertical, high-speed engine direct-connected to a generator used for lighting the plant. The valves and bonnets were removed from the cylinder but had not been oiled to prevent rusting. The cylinder heads were removed, but the interior of the cylinder and the pistons were not oiled; this was the case with the boiler feed pumps also. All internal and external parts of the generator engine were badly rusted. The new owners had much expense and delay in getting the plant into running order again.

It is a good plan, when a plant is to be shut down for an uncertain time, to put all apparatus in such a condition that they will not rust and will be ready to be started again in a short time.

## A Dangerous Layout

A manufacturing concern found it necessary to find space for storing coal for a few months. As there was no space available in any part of the building or yard, it was decided to make space in the boiler room, as there was a space of about 10 ft. between the boiler wall and the building wall running the length of the boiler room. The partition A was placed next to the boiler setting, as shown in Fig. 5, but, in placing the partition, there was left a space of only 14 in. between the partition and the blowoff valve, and, as this partition was run the full length of the boiler setting, the fireman or engineer would not have much chance of getting out should anything go wrong with the blowoff apparatus.

There are many ways of wasting steam in a boiler room. I know of one instance where an engineer who did his own firing in a plant, which consisted of one boiler and a high-speed engine, kept the safety valve continuously blowing off. He did not close the draft doors or stack damper when the pressure was near the blowing off point, but merely allowed the valve to blow. When it stopped more coal was thrown on the fire; in




SHOWING A NUMBER OF METHODS OF CURING POWER PLANT TROUBLES

this way the valve was kept blowing off most of the day. One can imagine what coal was wasted in this plant.

The engine in this plant is oiled by the splash system. Three hours after this man took charge of the plant the babbit was melted out of the crankpin boxes, while the two crank shaft bearings were quite hot, due to lack of oil in the crank case. In starting up that morning the engineer did not examine the crank case to see if it contained sufficient oil. After the engine was in operation no more attention was given to it until it started to pound badly when the babbit had melted.

### Tilting Trap Troubles

A tilting trap for boiler feeding gave trouble at times by not feeding sufficient water into the boiler. Although the trap was of ample size, the trouble was caused by the trap tank not filling up as quickly as it should.

I took the matter up with the maker of the trap, who advised me to drill and tap the bonnet on the inlet check valve for a ½-in. pipe, as shown in Fig. 6, at A. A short piece of pipe, an ell, a short nipple and a swing check were then fitted up, as shown in Fig. 7. This arrangement is for the purpose of admitting air into the inlet pipe when water runs into the trap tank. After this the tank filled much more quickly.

### Faulty Pipe Works

Figure 8 shows a piece of work in an office where but little judgment was used as to the appearance and amount of pipe and fitting used. The illustration shows the last radiator on the steam feeder line, also the apparatus for keeping the feeder line clear of condensate. This trap was located about 14 ft. from the last radiator and was arranged as shown at A and B; 14 ft. of 1½-in. pipe and one 1½-in. elbow were unnecessarily used on this job.

One day we were in need of 1½-in. pipe for a repair job. As there were none in stock and the pipe was needed badly, I thought of that needless pipe in the office heating system. This was ripped out at once and used on the repair job. To keep the radiator feeder clear of condensate, the trap was placed as shown at C. A close nipple was screwed into the tee D, next to the radiator line, then an elbow into this nipple. The nipple, tee, trap, and sediment chamber were then placed, while the outlet from the trap was connected into the return pipe close to the radiator.

While visiting a power plant recently, I noticed that the boiler feed pumps were set about 24 in. higher than the floor line. I thought this was a good idea, so, at the first opportunity, I raised my pumps to this height and found it convenient when packing the water pistons or rods and making repairs.

It is not necessary to make the foundation out of concrete. In my case, I used 12 by 12-in. timbers, rigged up as shown in Fig. 9.

### A Handy Boiler Platform

In many boiler rooms, the return tubular boilers are set 48 in., or thereabouts, from the grate surface. This makes it unhandy when cleaning boilers or making repairs at the front head, due to the fact that the tube doors are located quite high above the floor, making a movable platform necessary. My boilers are set 48 in. from the grate surface and we use a platform of the type shown in Fig. 10. It is made out of 2 by 4's and 1 by 4-in. strips, all hard wood. To hold the platform at the boiler front, a 2 by 4 is placed across the boiler front and held there with chains fastened to the tube door hinge bolts. As there is a door in the building wall opposite the boiler front, a 2 by 4 is lagged across the door opening and the other end of the platform is laid across this, as shown in Fig. 11. When not in use, the platform is hung against one of the boiler room walls.

### Examine Stack Guy Wires Frequently

One morning, while coming to the plant, I noticed that one of the guy wires was down. In examining the wire, I found it was rusted so badly that it had broken. I did not expect this, as the guys were up only a short time. In examining the other guys I found that they, too, were in bad condition; some of the strands were nearly rusted through. I lost no time in getting the guy wires replaced as quickly as possible. After this experience, I made it a practice to examine them more frequently.

Our boiler room doors are locked with a padlock. During the winter months we had much trouble in unlocking the lock, due to the fact that, whenever it rained during the night and turned cold, the water in the lock froze and much time was wasted in thawing out the ice. To prevent this trouble, a covering of heavy roofing paper was placed over the lock, as shown in Fig. 12.

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# Developments at the Glendale Power Plant

Blake Tells Wallace That Conditions Are Such That the Manager Would Be Glad to Get Him Back. By G. H. Kimball

DEAR WALLACE: I was much interested in your last letter, and it is some problem to get that unit that you have just moved in into line and I don't blame you for not wishing to take the responsibility. It would seem as if a company the size of the Bridgeton Glass Works would be glad to get an erecting man from the shops.

Since my last letter there has not been much change here. After pulling the stuck piston out of the cylinder that became overheated we put in new rings and now have the engine ready to run again. I thought that we would see some high-class work on this unit, with such a man as Gooch claims to be, but nothing of the kind has developed yet.

When you left here, the walls and roof of the plant were fairly clean, but you should see them now; the roof is black and the windows resemble those in a locomotive round house. I believe that you said something about their being troubled with smoke down there before you came; well! that is just what we are having here and it shows that there is something wrong.

I asked Gooch what the cause of it was, and he said that the engine had gotten into such bad shape that it would do that until it was fixed. I hope that he fixes it

pretty soon, for with it the way it is now, we don't know where we are.

Gooch seems to think that the boilers need repairing around the water columns, for he has taken the whole thing off the older boiler and the whole rig is lying on the bench for some of us to put back. All the trouble was, that one of the gage cocks leaked a little.

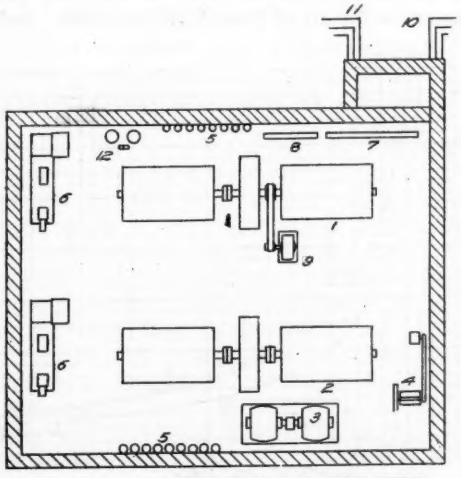
There is so much to do and nobody to lead the way. I was up in the office the other day and Wilbur, the manager, was speaking of you, so I said that I thought that you would be a cheap man at double the price that he is paying now. He said that he believed that you were not satisfied down there and he would pay you well to come back; if that interests you, we shall all be glad to see you again.

I hope that everything is going well and that I shall hear from you soon.

Your friend,
JOHN BLAKE.

WALLACE CONSIDERS ACCEPTING HIS OLD JOB, A STEP BACKWARD

DEAR JOHN: It now seems as if Gooch has shown what kind of a man he is and it is plain that Wilbur is



PLAN OF THE POWER PLANT AT BRIDGETON

not satisfied with him. I think you understand my position in the matter. We have discussed it so many times that nothing more can be added. I think that as far as the service went, Wilbur was well satisfied with my work at Glendale; but he thought that others who could do as well or better would be easy to obtain. The experience of the past year proves that it is not so and yet he could not show that he appreciated my work. Now that the plant is in bad shape, he would welcome me back. I believe that it would be a step backward for me to try it again and so it stands.

You will be interested to know that we have the old unit assembled and were able to turn her over last week. It does not look as if the connections had been adjusted for some time before they stopped running her for there is ⅛-in. play in some of them. In your unit the dowel pins that hold the crank box shims in place are on the bottom half of the box so that you can spread the halves and lay the shims over them and draw up on the bolts. On this unit they were placed in the top half so that we have to hold them up by hand until the pins have entered into the holes in the bottom half or those light shims will get out of place and the pins will cut them. I think that we will take the boxes out and have the pins changed.

Mr. Curly, our superintendent, was very glad to see her carry the whole main factory load the other day and I think that she is going to tune up all right.

Ever since they started to run engines in this spot they have been using city water for cooling them and as the reservoirs are getting low, they have decided that the water in the river is good enough, so we have a triplex pump like the one at Glendale run by a 5-hp. motor. It is hardly large enough for both units in warm weather, for the water comes out pretty warm.

Everything is housed in now so that we are somewhat protected from the weather. The switchboard is of wood and, like many other things, is only temporary until the new building is up.

The present arrangement is shown in the sketch herewith, which is a plan view of the arrangement of the machinery; 1 and 2 are the oil engine units which are coupled to the generators in the center; 3 is a 35-kw. exciter set with a synchronous motor taking current from the direct current end. This machine was a mystery to me, for I always thought that a synchronous motor had to have an induction motor to start it and bring it up to speed so that it could be thrown in parallel; but this machine starts with the usual compensator and it pulls into step after it is up to speed. It is quite a machine all right and it has some extra coils in the winding so that it starts like an induction motor; 4 is the cooling water pump, 5, 5 are banks of air bottles; 6, 6 are the air compressors of which I have written you before describing them; 7 is the main switchboard and 8 is the auxiliary board; 9 is an exciter driven from the first unit by a belt to the coupling; 10 is the feed line to the lower works and 11 the line to the upper works; 12 is the gravity oil tanks, one for each unit from which the fuel oil flows to the governor pumps. They are filled with a hand pump from a barrel which is filled from the main storage tanks.

This arrangement is about what will prevail when the new power house is built over the top of the wooden building, but the smaller parts will be moved. The work of laying out the foundations of the new building has already commenced and I expect that we shall be bothered considerably by the workmen.

I know a man down here who would like to have a job like running that plant up there and I have advised him to write to Wilbur about it. I think that I shall come up for a day or two shortly and we can compare notes, so goodbye until I see you.

Your friend,
WILLIAM WALLACE.

## Correction Note

IN FIG. 98. on page 474, of the May 1 issue, the leads from the mains to the transformer primaries were designated, in error, as 110 v. The figures should have been 2200 v. on the primary and 110 v. on the secondary.

EVERY man's pet pride is that man's pet weakness.

## Pressure-Volume-Temperature Relations of Gases

THE RECENT discussion in the columns of Power Plant Engineering regarding absolute zero temperature, and especially the letter by Charles J. Mason, in the May 1 issue, page 488, have been very interesting. Mr. Mason based the chart which he constructed on the assumptions of Boyle's Law and Charles' Law. Boyle's Law states that the pressure of a given mass of gas at constant temperature is inversely proportional to its volume. Charles' Law states that the volume of a given mass of any gas, at constant temperature, increases for each rise of temperature of 1 deg. F. by a constant fraction (about $\frac{1}{493}$) of its volume at 32 deg. F.

These two laws, when combined, are conveniently expressed as follows:

$$\frac{P_1 V_1}{T_1} = \frac{P V}{T}$$

in which P and V represent respectively the pressure and volume at the initial absolute temperature T, and $P_1$ and $V_1$ respectively the pressure and volume at the final absolute temperature $T_1$.

If we desired to solve the formula for $P_1$, it would take the form

$$P_1 = \frac{P V T_1}{V_1 T}$$

For example, if

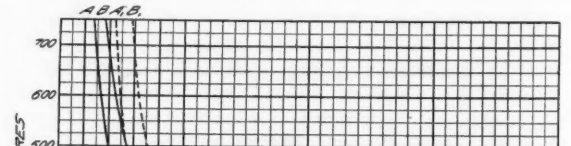
$P = 3$ atmospheres
$V = 2$ volumes
$V_1 = 4$ volumes
$T = 60$ deg. F. $= 521$ deg. abs.
$T_1 = 100$ deg. F. $= 561$ deg. abs.

Then $P_1 = \frac{3 \times 2 \times 561}{521 \times 4} = 1.614$ atmospheres

It will be seen that this formula is very convenient for solving all sorts of problems relating to gases. Mr. Mason explains that the slightest curvature of the line OD (see Mr. Mason's letter) would change the location of the point commonly regarded as absolute zero, namely, —461 deg. F. Nobody has ever been able even to approach such a low temperature as this, hence the behavior of gases at such low temperatures cannot be determined other than by speculative methods, and it is not surprising that different authorities cannot agree on an absolutely fixed point as the absolute zero.

Scientists have investigated the behavior of gases under all sorts of conditions and have found that they do not adhere rigidly to Boyle's Law. Under moderate pressures and temperatures, the discrepancy is so small that it can scarcely be determined; but under very great pressures, say around 100 atmospheres (about 1500 lb. per sq. in.), air departs appreciably from Boyle's Law, the difference amounting to about 2 or 3 per cent at that pressure.

Starting with unit volume and unit pressure, curve A represents corresponding volumes and pressures for air at a constant temperature of 32 deg. F., according to Boyle's Law. Curve $A_1$ shows the true pressure-volume relation above 100 atmospheres under the same conditions. Curve B is a similar Boyle's Law curve for air at 211 deg., while curve $B_1$ is the true pressure-volume curve for air at these high pressures. Referring




PRESSURE-VOLUME RELATIONS OF AIR. $A_1$ AND $B_1$ TRUE VALUES. A AND B VALUES CALCULATED BY BOYLE'S LAW

to curves A and $A_1$, it will be noted that at 500 atmospheres the actual volume is 0.002,68, whereas, according to Boyle's Law, it should be 0.002. In other words, at this high pressure, it becomes increasingly difficult to compress the air and the volume is greater by 0.002,68 ÷ 0.002 = 1.34 than it should be, according to Boyle's Law. Looking at this another way, it will be noted that it required 500 atmospheres to compress the air to 0.002,68, whereas, according to Boyle's Law, it should have required only 375 atmospheres to produce this volume. (See point on curve A above 0.002,68 volume and opposite 375 atmospheres pressure.)

In ordinary practice, these discrepancies may be ignored; but in dealing with highly compressed air or gases, many of which are supplied in cylinders at pressures considerably over 100 atmospheres, it is sometimes necessary to take account of these variations.

If such discrepancies occur at very high pressures, it is just as likely that the ordinary laws will not hold rigidly at extremely low temperatures, hence all the figures attributed to absolute zero at the present time may be a way off. Even if the commonly accepted figure of —461 deg. F. is a fiction, it is certainly a very handy one and answers all the purposes of ordinary calculations.

C. C. PHELPS.

## Improved Piston Rings

LUBRICATION of gas engine cylinders may be greatly improved by making the bearing surface of the rings at a slight inclination to the cylinder wall.

The two most common rings in use are shown in Figs. 1 and 2. The edges of both are very sharp, and will cut off a large amount of the oil from the cylinder wall, which will increase the wear on the cylinder and piston.

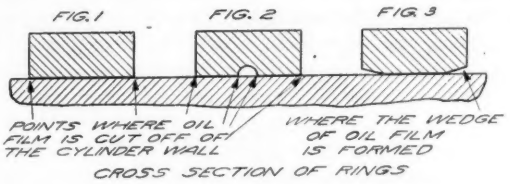


FIG. 1
FIG. 2
FIG. 3
POINTS WHERE OIL FILM IS CUT OFF OF THE CYLINDER WALL
WHERE THE WEDGE OF OIL FILM IS FORMED
CROSS SECTION OF RINGS

FIG. 1. COMMON TYPE OF PISTON RINGS
FIG. 2. COMMON TYPE OF PISTON RINGS
FIG. 3. PISTON RING WITH BEVELED EDGES

Rings like Fig. 2, with a groove in the center, are often used with the idea of improving the lubrication by holding a film of oil in the groove; this is impossible because the edges of the groove are at right angles to the bearing surface and will cut the oil off the cylinder just the same as the outer edges of the rings. Furthermore, there is no way to keep the groove flooded with oil.

The rule for efficient lubrication is that where two surfaces are in sliding contact, a satisfactory film of oil cannot be maintained unless the surfaces are at a slight inclination to each other.

A ring with the edges beveled, as in Fig. 3, will conform with the rule of lubrication; the edges, being beveled, will allow the oil to form a wedge film under the ring, which will give perfect lubrication and lengthen the life of the cylinder and rings.

The bevel of each edge should not exceed 20 per cent of the bearing surface and the depth of the cut should not exceed 0.012 in., depending on the size of the ring. If the bevel cut is more than 0.012 in., it will destroy the effect of the wedge shape of oil film.

H. P. DOERING.

## Feed Water Treatment

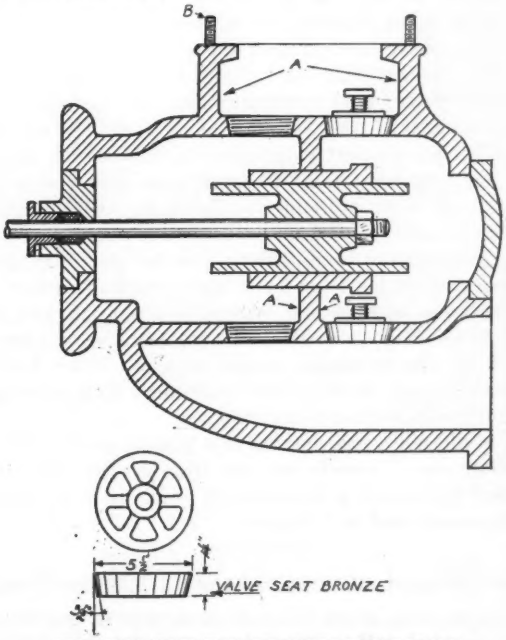
IN THE May 1 issue, page 489, H. W. Rose tells us that all our boiler room troubles are at an end when we have dug a hole in the ground to hold some water, and installed a 50-gal. water tank over the pumps, connecting a pipe with a valve between the tank and the suction pipe, through which runs a tested solution of chemicals.

Many of our cleverest scientists and engineers have been experimenting for years, trying to solve the boiler feed water problem, and at this date our troubles along this line are not at an end. The gentlemen referred to have lessened our troubles to a considerable extent, but they have not ended them by any means.

An analysis of the feed water and a knowledge of the proper chemicals and the quantities of such chemicals to use in treating a given quantity of the water, will, with the addition of heat applied to the water to raise its temperature to 305 deg. F., greatly assist in removing scale-forming material and other undesirable matter from the water. But what then? In many cases, the composition and quantity of matter in the water varies, and to be even moderately free from feed water troubles, it would be necessary to have an analysis made of the water at least once a week. I believe many do this very thing. Their troubles are never at an end.

The pond in the earth is a doubtful help. It is quite possible that such a pond will increase the trouble, as contact with such earth may increase the acid content of the water; this means another help toward pitting.

When hot process water softeners are operated and attended to in an intelligent manner, they are said to give excellent service.




SHOWING HOW THE CHANGES WERE MADE

I imagine there is little doubt that feed water impurities should be removed as much as possible before the water enters the boiler; treating the water with the compound before it enters the heater appears to be much in favor.

It has been said that water will dissolve anything in the world; some things very slowly, others very fast. It is some of these dissolved things the water has collected that cause many of our boiler troubles.

JAMES E. NOBLE.

## Remedy for Loose Pump Valve Seats

HEREWITH is a sketch illustrating how the expense of a new water end of a duplex pump may be saved. We have three pumps, all of the same size, the valve

seats of which would become loose and strip the threads in upper and lower decks. We retapped the holes and screwed in new valve seats, until the holes became so large that the edge was at the side walls marked A, so I had to stop tapping the holes. When the first two became too large, I machined the valve seats 1/32 in. larger than the hole and pressed them in using studs, B, to get a strain on them and then drove them up tight with a sledge, using a shaft very near the size of the valve seats. Two valve seats were pressed in last February and were examined about three weeks ago and found O. K. I face off the valve seats after pressing in.

W. F. JOHNSON.

## Used Boilers

THE WRITER wishes to take issue with N. G. Near anent the used boiler proposition, especially the last line, in which he makes this assertion: "True, a secondhand boiler is worth something as junk. I don't know the exact figure, but let us place it at 98 cents and 9 mills."

Given the gray matter we are supposed to possess, we fail to see why the foregoing should be true. There are plenty of ways to distinguish the good from the bad, so let's not condemn all of them just because they happen to have seen former service.

Now, the writer is not selling used boilers, or anything else in the used machinery line; but he does know of any number of used boilers that he would not hesitate to advise his present employers to buy, which would beat our own practically new boilers a thousand ways.

If N. G. Near will stop and think, he will, no doubt, be able to call to mind many instances where perfectly good boilers have been thrown out for perfectly good reasons and are good for many more years of service.

We know of three old boilers that were thrown out after 18 and 20 yr. of service that were still being allowed 100 lb. by the insurance people, and the writer knows, personally, they were in fine condition. Two were sold for $800 each before being removed.

I would not advise buying this kind of boiler without investigation; I merely cite the instance the show that all used boilers are not necessarily junk, as N. G. Near's article would lead us to believe. J. L. T.

## How Much Lubricant Does an Engine Need?

I READ, with much interest, an article in the May 1 issue, entitled, "How Much Lubricant Does an Engine Need?" by W. F. Schaphorst, in which he tells us that a 550-hp. cross-compound engine requires 15 gal. of oil per hour.

If Mr. Schaphorst is in the habit of using 15 gal. of oil per hour for a 550-hp. engine, I'd like to know how he gets away with it.

For some time, during the war, I was third assistant engineer on one of our transports, the U. S. S. Liberator, a 10,000-ton ship. We had a 3000-hp. triple expansion engine, which usually turned about 75 to 78 r.p.m., a two-ton and a four-ton ice machine, a 25-kw. generating set, self oiler, force feed, blower engine, two boiler feed pumps, fresh water, sanitary, circulating, bilge and air pumps and also six spring bearings in the shaft alley.

The bearings on the main engine and shaft were oiled by the wick feed siphon system, supplemented by hand oiling every half hour, and the minor bearings, such as valve gear, etc., oiled every hour.

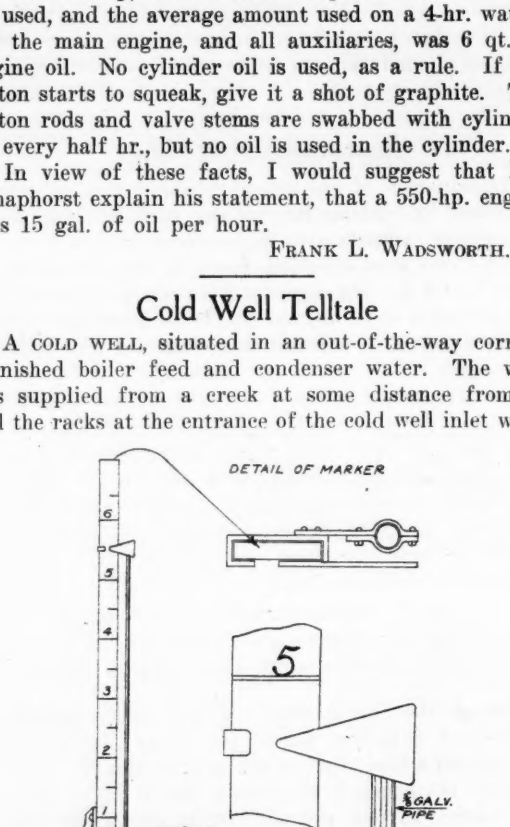
Aboard ship, strict watch is kept on the amount of oil used, and the average amount used on a 4-hr. watch, for the main engine, and all auxiliaries, was 6 qt. of engine oil. No cylinder oil is used, as a rule. If the piston starts to squeak, give it a shot of graphite. The piston rods and valve stems are swabbed with cylinder oil every half hr., but no oil is used in the cylinder.

In view of these facts, I would suggest that Mr. Schaphorst explain his statement, that a 550-hp. engine uses 15 gal. of oil per hour.

FRANK L. WADSWORTH.

## Cold Well Telltale

A COLD WELL, situated in an out-of-the-way corner, furnished boiler feed and condenser water. The well was supplied from a creek at some distance from it and the racks at the entrance of the cold well inlet were




ARRANGEMENT OF TELLTALE IN COLD WELL

continually clogging with leaves and other debris. To make sure of his water level, the engineer had to leave his engine frequently, and often found the situation rather serious. Lost, or nearly lost, vacuum, and low feed-water are serious when both happen together. not to life, necessarily, but to the mill's efficient operation; and it set the chief to thinking. He fashioned a telltale and set it up where both the engineer and the fireman could see it without leaving their posts. The drawing explains itself. CONDENSER.

## Engineers' License Law

HAVING READ about all that has been written about Engineers' License Law, it seems as if every writer on the subject has a different view on how the law should be framed up. Some want the engineers classed in about

three classes, namely, No. 1, No. 2 and No. 3. I contend that, if you start the grading process, and give every man just what is coming to him, you will have the biggest job you ever tackled; for, in my experience, I have not fingers and toes enough to count the number of classes that I have met.

Joseph J. Zlabis has a very good article on the Bureau of Mines putting out a guarantee on the evaporation of their coal. This is just the thing to do, but I fail to see where you can use this miners' guarantee on evaporation to grade the engineers. Mr. Zlabis says to weed out the incompetent from the real engineers. Now, in my mind, when you say weed out, that is a very large term, and I would like somebody to tell me where you would start the weeding process.

In my opinion, an Engineers' License Law should provide for a license for every man who is operating, prior to the passage of the law, as an engineer, provided said operator fills out an affidavit signed by his employer to operate that power plant only. Now, in case this man desires to make a change in his position to take charge of another steam plant, then he must go before the board of examining engineers to stand the test as to his ability as an operating engineer. Also, I would recommend that in all cities that already have a city license in force, the licenses be honored just the same as before, and should the man holding a state license want to go to any of the cities having the city license in force, he should be required to go before the board of engineers and secure a city license to operate in the city. We, as operating engineers, should not allow anything to come between us and our employers, except perfect harmony.

I feel that, should we ask for a state license on the above line, 90 per cent of the power plant owners would be glad to help land a state license law.

F. O. Schlosser.

## Filing Magazine Articles

In the May 1 issue, page 491, under "Remarks on Issue of April 1," I. B. Leavit describes an excellent method of filing magazine articles. It appears, however, that, after he has sorted and filed the various articles of an issue, he discards all the advertising pages, together with the Signboard Section. It seems to me that, if a man is interested enough to file away the reading matter, he should be equally interested in the addresses of the various manufacturers connected with the profession. This is particularly true of the buyer or of the man who recommends apparatus for purchase. The want column also may be worth keeping to the man that is seeking a new position or to the man who has charge of the employing of help.

H. W. Rose.

The suggestions, in recent issues, regarding the filing of magazine pages with useful articles are good, but I believe that a card index system is more expansive and at least as easy to look over.

In a box wide enough to hold the width of a page and as high as the folded page, I have the articles filed behind index cards which have the protruding indicating tags arranged in staggered formation so as to make them plainly seen; the cards are arranged in alphabetical sequence.

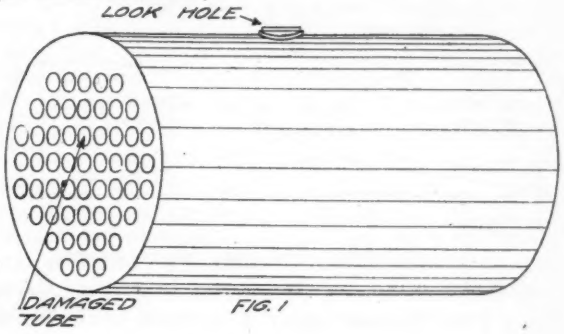
If one or more subjects is of such interest for the reader that the articles accumulate fast, they can easily be subdivided by inserting additional index cards behind the first one. New subjects can also be added at any time without upsetting the arrangement.

If somebody would contribute a few articles on supplies and stock-keeping records, I could find room for them in my file.

E. Matzan.

## Re-Tubing a Bent-Tube Condenser

A damaged tube in a bent-tube condenser had to be replaced. The damaged tube was not located in the extreme top row and therefore the new tube could not be reached through the look-hole so as to bend it and direct it into the corresponding hole in the opposite end of the condenser.



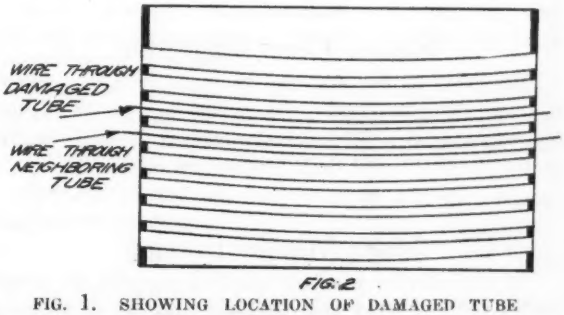



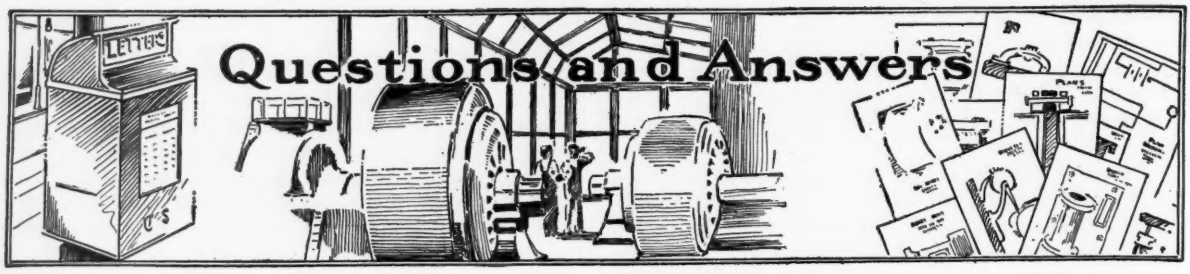

Fig. 1. Showing location of damaged tube
Fig. 2. Method used to guide new tubes into place

Before removing the damaged tube, we placed a wire through it; the wire was intended to serve as a guide for the new tube.

It happened, however, that the wire was pulled out, together with the damaged tube. Now, to solve the puzzle, we used a light wire bent at one end and by turning and swinging the latter we attempted to reach the opposite hole. We also removed, temporarily, a neighboring tube in order to make it easier to strike the hole. The operation was successfuly performed.

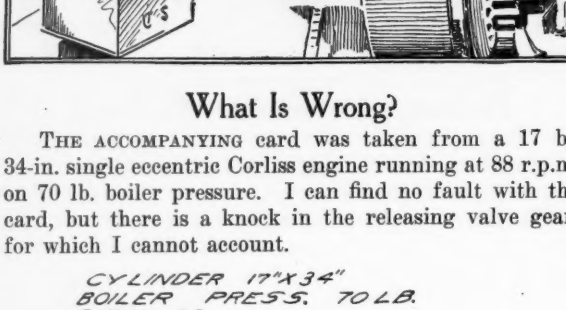
B. A. Wachutin.

U. S. Civil Service Commission announces an examination, June 29, for designing engineer, electrical and mechanical, or radio, to fill vacancies in the radio laboratories, Camp Alfred Vail, Little Silver, N. J., and in positions requiring similar qualifications throughout the United States, at $2500 to $3000 a year, or higher or lower salaries. Apply for Form 2118.




## What Is Wrong?

THE ACCOMPANYING card was taken from a 17 by 34-in. single eccentric Corliss engine running at 88 r.p.m. on 70 lb. boiler pressure. I can find no fault with the card, but there is a knock in the releasing valve gear, for which I cannot account.




CARD FROM SINGLE ECCENTRIC CORLISS ENGINE

I would like to have the opinions of other readers of Power Plant Engineering as to the cause of the knock.

J. S. M.

## Exciter Loses Magnetism

WE HAVE a 200-kw. exciter on a 1000-kw., 440-v., a.-c. turbine generator, which, at times, loses its residual magnetism. Is there not some method of shutting this exciter down so that it will retain its magnetism?

H. E. S.

## Using Metallic Packing

IS IT desirable to place metallic packing on a new piston rod? I mean that packing made up of sectional cast-iron rings, confined in a case. I am acquainted with two erecting engineers who hold different opinions on this subject. One claims it is better to place the new packing on the new rod, and let them wear to a bearing together. The other claims it is better to use a soft pack on the rod for a week, or longer, if necessary, until the rod has a glaze. Then apply the metallic packing, and it will soon adapt itself to the rod. While the wear on the rod, during the use of the soft packing, will be negligible, a great advantage will be obtained in having the rod glazed. The metallic packing will work better on the glazed surface, whereas it is liable to scratch or score the rod if placed on a fresh rod. Also by using soft packing at first, any little dirt which may be in the cylinder, tending to work out through the stuffing-box, will be better taken care of. I would like the opinions of engineers who have installed metallic packing on their rods, as to their experience.

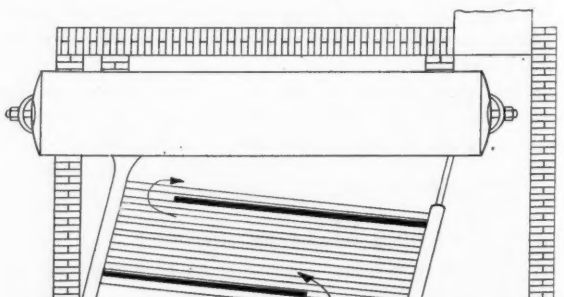
When soft packing is used on a piston rod, is it good policy and practice not to use an oil cup containing cylinder oil for dropping oil on the piston rod? An old engineer told me he never oils the piston rod when packed with soft packing, as the oil is injurious to the packing, and rots it out; that the rod gets sufficient lubrication from the oil fed into the cylinder.

In every engine room in which I have ever been it has been the practice to have an oil cup for oiling the piston rod placed on the guides. What do the engineers think?

TOM JONES.

## A Smoke Problem

I HAVE A problem on boiler design and operation that I would like to submit to readers of Power Plant Engineering for criticisms or suggestions. The accompanying illustration shows a general outline of boiler construction. The plant consists of three 175-hp. B. & W. boilers, hand fired, as shown, two of which are used at one time.




ARRANGEMENT OF THE BOILERS AND FURNACES

Our great trouble has been the smoke nuisance. As shown at A, the boilers are equipped with a steam blower under the grate. Steam pressure is maintained at 110 lb., and when this drops to 105 lb. an automatic valve opens the stack damper wider and also starts up the steam blower. When the blower starts, the firemen immediately get busy with their shovels and put on a fresh charge of coal.

The fire door is equipped with a smaller door, as shown at B, which closes slowly by clockwork mechanism after the fire door is closed. The purpose of this small door is to admit air over the fire after a fresh charge of coal to aid combustion and help reduces the smoke. I may mention that the stack affords sufficient natural draft for all three boilers. For 5 min. after firing, the

smoke coming from the stack is enough to make any inspector swear.

Any advice regarding changes in the boiler design or method of firing to reduce smoke will be appreciated.

A. R. K.

## Electrolysis Problem for Solution

THE WRITER has several refrigerating systems employing brine and which are disintegrating, due to electrolysis. The brine tanks are of steel, lined with 4 in. of cork, and are set in concrete pits in the ground. The pits are well drained. The brine pump draws from the bottom of the tank, discharges through a double pipe brine cooler, which is suspended immediately over the tank and out of the brine, and from the brine cooler the brine runs through pipes about 100 ft. long, leading to a large brass tubular cooler, which is used for cooling our liquid product.

We have eliminated all brass except a valve on each side of the brine pump and the brass cooler. The entire system from one end to the other is disintegrating, except the brass parts.

Can anybody tell us at what intervals in the system we must place zinc in order to make all of our equipment electrically positive so that the zinc only will be attacked?

R. O. H.

## Blowoff Strainers; Are They Safe?

IN THE issue of Power Plant Engineering of May 15, C. H. asks whether strainers over blowoff pipes are safe or dangerous. I think this is a very poor installation, and as there can be no benefit derived from these strainers, they should be removed before something serious happens, as the sediment will accumulate around them and close the small openings in a short time, even if the blowoff is opened at the regular intervals. I have known of feed pipes being stopped at the point where the water entered the boiler to such an extent as to necessitate the boiler to be cut out and the pipe cleaned. If the intention is to feed through the blowoff, the conditions would be even more serious, as the water would be retarded at the strainer, causing the sediment to adhere to it and cut down the supply of the feed water.

Bulletin No. 14, of the State of New York Industrial Code, relating to steam boilers, reads: "Par. 310. The blowoff pipe or pipes shall be extra heavy from boiler to valve or valves, and shall run full size without reducers or bushings. All fittings between the boiler and valves shall be of steel."

C. J. MILLER.

## Criticism of a Corliss Card

FROM an examination of the indicator card of an 18 by 42-in. Corliss engine presented for criticism by C. R. in the May 1 issue, I am inclined to believe that the engine is not consuming steam as economically as it might be. The eccentric, no doubt, has been changed from its original factory setting, as the movement of the valve gear appears to be sluggish. In other words, the piston, for proper expansion of steam, is moving too fast for the rate at which the valve is opened to admit the steam before cutoff. This does not allow full use to be made of the expansion of the steam. While the compression at both ends is fair, it would be more economical to secure more compression if this could be attained without creating any bearing or pin troubles. With these changes, taking it for granted that the valves and seats are in good condition, C. R. should have the engine in an economical condition.

H. W. ROSE.

## Why the Knock?

IN REGARD to J. L. S.'s letter, on page 401, of the April 1 issue, I relate the following experience:

I was called in consultation on a case of a 14 by 36-in. Corliss engine which knocked at the end of the stroke. This engine had been newly bored out and fitted with a new piston and sectional four-part rings.

By changing the piston position slightly in either end, the knock could be changed to either end. As you know, a slot for sectional rings is much deeper than with a snap ring construction and generally has more space under the rings. As the piston was a very close fit in the cylinder, I took out the rings and when I started up the engine the noise had entirely disappeared.

Upon examination, the rings showed wear on the ends of the sections, from butting together.

This was due to the rings fitting too tight in the slot and not allowing steam to pass down under the ring to balance the top pressure on the ring when passing by the counterbore, 1/16 in. When in this position, induction steam drives the ring down in the slot and butts the ends together.

Moral: Have the ring fill the slot completely between wall and bottom as near as possible and do not have it entirely fit sidewise.

In my case, there was no difference in steam consumption with the rings in or out, as the piston was a neat fit, but it saved one cord of wood in a 24-hr. run, out of five cords used before reboring.

I ground off the sides of the rings and the trouble disappeared entirely.

JOHN D. ULLEY.

## What Caused the Bag?

IN HIS letter in the April 15 issue, J. A. H. did not state whether his engine is run condensing or noncondensing. If it is run condensing, in connection with a surface condenser, it is possible that oil was carried back into the boiler with the condensate, and deposited on the shell. Oils, whether animal or vegetable, are frequently the cause of bagged boilers.

G. R. COSTE.

IN REGARD to J. A. H.'s experience, I have formed the following opinion as to the cause of the boiler bagging: The excessive firing had overloaded the boiler to such an extent that the steam pressure was temporarily kept up. This, however, caused such a rapid circulation of water in the boiler as to produce a steam pocket, due to the rapid upward velocity of the two circulating streams at the point where they met. This point was just above that position of the shell where the bag occurred. As there was no water in contact with the shell at this point, and, due to the intense heat

of the furnace, the shell naturally became weak and bulged downward on account of the high steam pressure inside the boiler.

Quite a number of years ago, in a battery of three return tubular boilers, in a plant of which I was engineer, I encountered considerable trouble along the same line. On a Christmas Eve, when the plant was running at or above its peak load, I had an experience similar to that of J. A. H. with the center boiler, and it required considerable diplomatic persuasion the next day to secure the services of a boiler maker and two helpers to repair the damage. Some time later, when the opportunity presented itself, I removed the two downward middle rows of tubes directly in the center of each boiler, and thereafter I encountered no more troubles of this nature. The boiler could afterwards undergo severe overloading; in fact, sometimes to such an extent that the firebrick lining would actually run together, but bagging never occurred.

H. W. Rose.

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This question was asked by J. A. H. in the April 15 issue, page 446. I should consider that the scale which he took out the next morning had settled down during the forcing of the boilers, and, as the water could not get to the plate, it became overheated and bagged. If the boiler plate was clean, it would not matter how much the boiler was forced, as the water would conduct the heat away.

I never have believed in drawing a fire if there was any other way to kill it (like ashes or wet coal). By drawing a fire there is an intense heat created until most of the fire is out of the firebox, and in some cases firemen have not been able to stand the heat all this time.

He also asked if two engines, carrying 170 amp., can be driven at a speed of 277 r.p.m., each engine rated at 125 hp. As he does not give the voltage or resistance, I will assume that both engines are doing 125 hp., or a total of 250 hp., and using 30 lb of steam per hp. $250 \times 30 = 7500$ lb. of steam necessary. One boiler horsepower is the evaporation of 34 lb. of water from and at 212 deg. F. If these conditions exist in the above case, then $7500 \div 34 = 220$ boiler hp., which are necessary to develop 250 hp. at the engine. This would be hard forcing for a 150-hp. boiler. The speed of the engine does not enter this problem, but the total steam consumption of the engine does. W. N. L.

## Grates Burn—Proposed Remedy

On page 446, of the April 15 issue, Richard Carl relates his furnace troubles and proposes a remedy. The explanation, while clear, is not quite as complete as it should be for a proper analysis of the problem. If the rated horsepower of the boiler had been given, together with the amount of power it was actually handling, we would have a working basis on which to estimate the capacity of the furnace. As a matter of fact, under the conditions stated, the boiler could be coated with a thick layer of hard scale, both in the tubes and in the shell, thus making excessive firing necessary to carry the required amount of steam. If that is not the case, the trouble may be due to a leaky boiler setting, or insufficient stack draft. It is further to be borne in mind that some coals are better adapted to certain stokers than others and it may be that, in this case, the stoker installed was not suitable for the kind of coal used.

If, however, the boiler is in good shape in every respect, with the exception of being overloaded, and the tiling is changed from the first row of tubes to the second row, it has been found in other cases that the circulation of water through the first row of tubes will be so materially increased that it will not flow evenly through the tube. Instead, it will flow through the tubes in gushes, leaving steam pockets between the gushes. This condition I consider dangerous, as it means a tube partially filled with water and being exposed to the high temperature of the furnace, in my opinion, the tube will bag. This may be the future experience of Mr. Carl if the boiler is overloaded and he makes the suggested change. His boiler may only need some of the former corrections which I have suggested.

H. W. Rose.

---

## What Changes Would You Make?

The following comments may be of service to J. P., page 537, May 15 issue, under the caption, "What Changes Would You Make?"

The valve setting and steam distribution in the high-pressure cylinder appear to be about as good as may be expected.

In the low-pressure diagrams, Fig. 3, improvement may still be made, I believe. The head end will stand a little more lead, and by increasing that, the height of the head end diagram may be increased. This is required for equalization.

The terminal pressure in the low-pressure cylinder—at both ends—is too high, due to a too low receiver pressure. Without going into calculations at present, I would think that with the given initial steam pressure in the high-pressure cylinder, and with the stated cylinder sizes, a receiver pressure of at least 15 lb. gage should be carried for best results. Of course, it is generally presumed that in a cross-compound engine, equal power should be developed in the cylinders. As the cards are at present, I do not think that the powers are equal. It looks as if the high pressure is developing more than the low. In any case, I am of the opinion that with any given load to be carried by the engine as a whole, that receiver pressure should be carried which will cause the governor balls to float in the highest plane. Then you will get a comparatively low terminal pressure in the low-pressure cylinder, which is desirable from an economical standpoint. In J. P.'s case, I believe a higher receiver pressure will prove of benefit all round. Why not try it out? And, let us know the results in a later story. Try 15 lb. as a starter.

Charles J. Mason.

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## Solution to Reservoir Problem

Replying to R. T.'S letter in the May 15 issue regarding the tapping of a reservoir, I wish to say that if I were going to do this job I would take a length of cast-iron pipe with a flange on one end, and, before emptying the reservoir, I would cut a hole into the brick work from the outside large enough to insert the flange end of the pipe and to a depth just so the water

would not break through. Then I would set the pipe into the wall, brick up close around the pipe, using good cement mortar, and leave this to set for two or three days. When sufficiently hard, empty the reservoir and open up the hole from the inside. In this way, you will not have your reservoir out of service over ½ hr.

M. G. B.

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In answer to R. T.'s request for a solution to his problem in the May 15 issue, I would suggest that he may tap his reservoir without interrupting its present service and have all the time necessary to make satisfactory connections at the base of the tank.

Supposing the reservoir to have a flat bottom, first secure a half round watering tank and saw the hoops off flush with the nuts that hold the cross pieces and the tank together. Second, strike an arc having a 30-ft. radius on a plank which will nearly fit the curvature of the reservoir wall. This plank will be fastened to the end of the tank.

Third, nail an inch strip on top of the staves, which will raise the sides above the hoop nuts and saw the end pieces at a sufficient depth to make all work come even.

Fourth, secure some old style, rubber manhole gasket material and nail it on the strips mentioned above, using small brads or tacks.

Fifth, take the improvised coffer dam to the place of operation and ballast one end until it just floats, provided the reservoir is nearly full. Work the dam into place and add ballast until it sinks.

Sixth, put a shore across to the opposite side of the reservoir and wedge the dam against the walls. Let the water recede as low as possible and put in another shore; then drive the wedges alternately until the gasket material fills all small depressions. If the work has been carefully done and with not too great irregularities in the reservoir wall, it should be reasonably water-tight. When the water is at the low point, pump or bail out the coffer dam, note the amount of leakage as the water rises to the maximum and, if not excessive, the wall may be pierced.

There are numerous ways of sealing the pipe to the masonry, but I would prefer to have the pipe pass through a stuffing-box which is cast with the wall.

Gasket material mentioned is round rubber about 7/16 in. in diameter having a 3/16-in. hole through its center.

G. C. Wetherbee.

---

## A Bridge-Wall Problem

The company I work for has two boilers—one a Dillon, and the other a Scanlon; the former is 19 ft. long, 6 ft. 6 in. in diameter and has 114 tubes. The latter is 18 ft. long, 6 ft. in diameter and has 138 tubes; the fire boxes are the same 6 by 6 ft. and our chimney is 100 ft. high with a good draft. Our superintendent wants to try new schemes all the time so has the bridge walls cut down so that they are 1 ft. 5 in. from the boilers. We have had trouble steaming them ever since. No matter how light or thick a fire you carry it burns out from the bridge walls in about 2 ft. 6 in., cannot keep any fire on rear end of grates and the front part most always bakes or cokes right over and has to be broken up. It never did that before he cut the bridge-walls down, and besides it takes more coal. One boiler is 200 hp. and the other 150 hp.; we carry from 80 to 100 lb. of steam.

I claim the bridge-walls are too low, and unbeknown to him I thought I would write somebody to see if I could find out how far from the shell the bridge-wall should be. Of course, it probably varies in different types of boilers, but I would like to have you give me the distance that a bridge-wall should be from a few different makes of boilers and how they should be built to get the right combustion or the correct mixture of air and gases. Please give me all the information you possibly can on this subject and I will be greatly obliged.

A. L. S.

A. We have your letter requesting information on the proper height of a bridge wall. For approximately the same size boilers as you have Kent in "Steam Boiler Economy" gives 12 in. as the proper distance from the top of the bridge wall to the boiler shell. He further states that the chief function of a bridge wall is to limit the length of the grate surface for presenting a barrier beyond which the spreading of the fuel is prevented. It also aids in mingling the unburned gases and air. The exact shape of the bridge wall does not materially affect these functions.

---

## Small Turbine Steam Consumption

Will you kindly send me some data on steam consumption on small steam turbines running noncondensing? I want this with both superheat and saturated steam.

C. D.

A. Gebhardt in "Steam Power Plant Engineering" states that noncondensing turbines operating with dry steam at 150-lb. gage and a back pressure of 0 lb. gage, have the following water rate per brake horsepower hour:

| Horsepower | Lb. |
|---|---|
| 25 | 43 |
| 50 | 38 |
| 100 | 32 |
| 200 | 29 |
| 500 | 27 |
| 750 | 25.5 |
| 1000 | 24.75 |
| 1500 | 24 |

He also states that with superheated steam the water rate is improved about 1 per cent for every 8 to 12 deg. F. superheat.

---

## Dashpot Trouble

There are several possible reasons for R. N. D.'s dashpot trouble. One is that the small check that releases the air at the bottom of the pot may be in bad shape. In the case of older style pots, another reason may be that the leathers are bad and should be reset or renewed.

The probable reason in R. N. D.'s case, however, is that the collar on the valve stem near the stuffingbox gland has worked loose, allowing the pressure of steam to face the valve stem against the bonnet inside of the cylinder. The remedy is, of course, to push the stem back and reset the collar, giving the stem a good counter sink at point of contact with the set screw.

John P. Hurst.

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CONTENTS


An Australian Electric Railway Power Plant. Illustrated....595

The Locomotive Crane in the Power Plant. Illustrated.....599

Alarm for Coal Storage Hopper. By M. A. Saller. Illustrated .....601

Osborn Monnett. By Walter Painter. Illustrated.....602

The Centrifugal Pump. Illustrated.....603

Correcting Turbine Balance. By Jay C. Wheeler. Illustrated.606

Production of Electricity by Public Utilities.....608

Industrial Illumination—I. By Victor H. Todd. Illustrated..609

Electricity. By Terrell Croft.....612

Industrial Plant Distribution. By J. F. Adler. Illustrated....613

Wear of Projecting Fibers on Belts. By W. F. Schaphorst. Illustrated .....614

The Adventures of Murdock. By A. W. Kramer.....615

Theory and Practice of Lubrication. By Henry M. Wells and James Ed. Southcombe.....618

Power Plant Troubles. By H. A. Jahnke. Illustrated....620

Developments at the Glendale Power Plant. By G. H. Kimball. Illustrated.....622

Letters Direct from the Plant: Pressure-Volume-Temperature Relations of Gases. Improved Piston Rings. Feed Water Treatment. Remedy for Loose Pump Valve Seats. Used Boilers. How Much Lubricant Does an Engine Need? Cold Well Telltale. Engineers' License Law. Filing Magazine Articles. Re-Tubing a Bent-Tube Condenser. Illustrated.....624

Questions and Answers: Exciter Loses Magnetism. Using Metallic Packing. A Smoke Problem. Electrolysis Problem for Solution. Blowoff Strainers; Are They Safe? Criticism of a Corliss Card. Why the Knock? What Caused the Bag? Grates Burn—Proposed Remedy. What Changes Would You Make? Solution to Reservoir Problem. A Bridge-Wall Problem. Small Turbine Steam Consumption. Dashpot Trouble. Illustrated .....628

Editorial: Industrial Illumination. Health in the Power Plant. New Ideas on Lubrication.....632

A New Friction Clutch. Illustrated.....634

Carl G. Barth Honored by Taylor Society.....634

News Notes.....635

Book Reviews.....635

Trade News.....636


## Industrial Illumination

At the time of the introduction of electricity as an illuminating agent, but little if any consideration was given the question of the economical use of the energy required for the purpose, lighting units were placed wherever their need at the moment appeared most necessary and the effect of the illumination provided upon the physical and mental welfare of the worker and the resulting efficiency of the working force were phases on the subject entirely disregarded. The prevailing motive appeared to be to provide light rather than illumination. In fact, but little was at that time known of the principles underlying the correct and proper application of light to the needs of man in the home, on the street, or in the shop or office.

Simultaneous with our commercial and industrial development came the demand for more and better illumination and as a result of considerable study, research and experimentation, scientists, engineers and manufacturers were instrumental in bringing about a revolution not only in the application of illuminating units but also in the design and construction of the lamps used. As a result, we are today able to obtain lamps operating on an energy consumption of less than one watt for each available candlepower (where formerly 3 to 4 w. per candlepower were required), and reflectors so designed as to provide for the most efficient use of the light available. Thus, with proper spacing and mounting heights of units fitted with the correct type and form of reflector, it is now possible to illuminate interiors to a degree and a quality well nigh approaching daylight.

For the sake of economy of electric energy, the physiological effect upon the worker and increased production which the world now so badly needs, it is imperative that every engineer and superintendent directly or indirectly in charge of a lighting system give this phase of his duties the attention it rightfully warrants and this regardless of whether the system be of an obsolete type or of comparatively recent installation. Progress in the development of industrial lighting equipment has been so rapid that the system installed but 2 or 3 yr. ago may today be found highly inefficient and even perhaps totally unsuited to render the service for which it was originally designed. Many will inquire as to how or where up-to-date and authentic information on the subject may be obtained. True it is, there are many excellent text books available and while the underlying theories presented in them may well be accepted, the sections devoted to the practical sides of the subject do as a rule not conform strictly to modern practice. That such is the case is obvious from the fact that considerable time must necessarily elapse between the date of the preparation of the manuscript and that of publication of the book.

In order, therefore, to give to the readers of Power Plant Engineering the most essential and timely data on this important phase of engineering practice, we have arranged to publish a series of articles dealing primarily with illumination as applied to the industries. The first of these appear in the electrical section of this issue, and while devoted entirely to the fundamentals of illumination, a careful and thorough study of this

installment and those following will, we believe, enable the student to solve almost any practical problem in industrial illumination with which he may be confronted. The material is presented in a most comprehensive manner and the examples of installations cited are representative of recent practice.

## Health in the Power Plant

In the hunt for the last B.t.u. in the coal pile, are we not overlooking one of the principal causes for losses in power plants? Engineers are so accustomed to dealing with machinery that too little attention is given to the human element involved, and one phase of this human problem is the sanitary condition of the power plant and surroundings. If these conditions are not what they should be, the work will not be performed with the same care and efficiency that obtains in the plant where human comfort and health are made of first importance.

Good housekeeping is one of the prime requisites of every building wherein people work; this means not only an orderly arrangement of equipment and keeping the floors, walls and windows clean, but the elimination of all vermin, insects and conditions that breed and spread disease. It is just as important that the place where a man works from 8 to 12 hr. during nearly every day of the year should be as free from disease as the home where he lives.

Why not make a little survey of the plant to find the possible breeding places for disease and the causes for ill health, then lay plans to eliminate them as far as possible?

Rats, mice, roaches, flies and mosquitoes are among the most common carriers of disease and have no place in the power plant and are more easily kept out of the plant than an ordinary home where food is a great attraction. Lavatories, closets, garbage cans and piles of refuse need the very closest of attention. Sunlight and fresh air play an important part in eradicating disease and wherever possible they should be provided.

In almost every power plant two conditions exist which are almost impossible to overcome; these are excessive heat and coal and ash dust in certain parts of the plant. As a result heat prostration and pulmonary troubles are common among power plant workers. Both of these conditions can be greatly relieved in nearly every plant by proper use of insulation, directing currents of air through the plant, and the judicious use of ventilating hoods and the water hose. Practical rules to enforce sanitary habits among the workmen should be drawn up and rigidly adhered to.

The engineer does not need to be told what conditions are and are not sanitary; in nearly every industrial and building plant, a good share of his services are used to promote healthful conditions for the inhabitants, but, like the shoemaker's children who go barefooted, his own department is frequently neglected. What is needed, however, is information on modern practical methods and means for performing such services as: handling refuse where such comes to the boiler room for fuel purposes, eliminating flying dust where men are required to work, maintaining comfortable temperature over boilers or in engine rooms where work must be done for any length of time, preventing sump gases from contaminating the air, permanently eradicating vermin. During the past decade much has been done in factories to make them healthy abodes, but too frequently the work stops short of the power plant possibly because of the comparatively few employes and the special problems involved. As an aid toward a betterment of sanitary conditions, the editors of Power Plant Engineering will welcome contributions from readers who have successfully met such problems as mentioned above. Let us not forget that a man is a human before he is an engineer and that ill health in a plant is one of the direct causes of inefficient operation of machinery.

## New Ideas on Lubrication

Coming to us from England is a new theory of lubrication which contradicts directly some of our former ideas, and, according to the authorities who have investigated and developed the theory, it simplifies greatly the compounding of lubricants for various services, thus reducing their costs materially. The presentation of this theory is indeed welcome to the power plant industry where immense quantities of lubricants for many special services are used; but as the data thus far comes only from a few interested persons, it will be some time, even if the theory is correct, before it is relied upon in general practice.

In substance this theory, which is presented in detail on other pages of this issue, attributes the friction-reducing qualities of oil solely to the fatty acid on the value of the surface tension of the lubricant. What these discoveries will mean to the industry can hardly be stated fully as yet, but it has opened up a field for general experimentation the result of which is likely to be a revision of many of our oil specifications and a change in our methods of testing oils to include a definite statement of the percentage of acidity and the surface tension value. It is stated that with the application of this new theory the oil refiner will be in position to modify the properties of his oils at will to suit the purposes for which they are to be used. If this is true, the uncertainty with which oils are quite commonly purchased will give way to definite standard specifications, which is an ideal sought for in all engineering practice.

THE NEW FOREMAN was a wiry little fellow. He started off wrong, causing much dissatisfaction among the men by fault-finding, and a lack of polish when suggesting corrective measures. The superintendent asked one of the old timers how things were running, referring more especially to the world in general.

"Everything fine and dandy, except your instantaneous heater, lately installed."

"Instantaneous heater! Why, we have no such thing around here."

"Oh, yes. That new foreman wasn't in the shop five minutes until every man there was hot in the collar."

# A New Friction Clutch

THERE ARE many places in the modern factory transmission system where friction clutches are necessary, especially in connection with machines which must be brought from a state of rest to high speed in a comparatively short time, without unduly straining either the shafting or the driven machine. A clutch designed to operate under these conditions must be strong enough to handle the load imposed on

FIG. 1. EXTERNAL VIEW OF CLUTCH

it. It must be balanced to eliminate vibration, and moving parts should be guarded as a safety precaution. The gripping surfaces should have a high friction co-efficient, together with good wearing qualities.

The new Twyncone clutch, recently placed on the market, incorporates these good points to a great extent. As will be noted in the external view, Fig. 1, most of the revolving parts are protected by a metal guard, which constitutes one-half of the casing. One of the unusual features of this clutch is the construction of

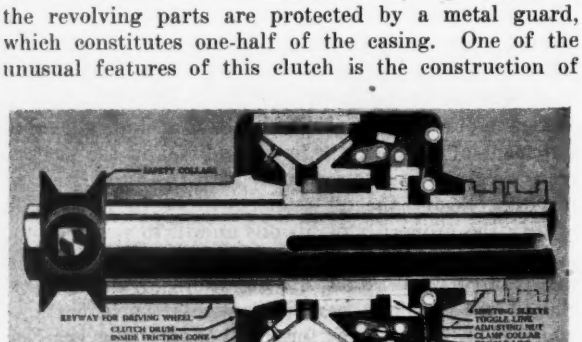


FIG. 2. CROSS-SECTIONAL VIEW OF CLUTCH

the gripping cones. A double cone is mounted in a cast-iron casing, keyed in such a manner as to allow a small longitudinal movement. When the clutch is engaged the double cone adjusts its position so as to equalize the pressure between it and the two single cones which are brought into contact with the double cone by means of the arrangement of toggles and links shown in Fig. 2.

The two single cones are faced with a material with a high co-efficient of friction, while the double cone, or friction ring, is of cast iron. The combination is said to wear well. The only adjustment required to compensate for wear is a slight movement toward the cones of the large adjusting nut shown.

Because the parts are all balanced, and freedom from vibration practically eliminates the possibility of the clutch being engaged or disengaged by action of centrifugal force on the various links and toggles. When the clutch is engaged no end pressure is necessary to keep the cones in contact, as the construction of the operating mechanism is such that the cones are effectually locked. This is clearly shown in Fig. 2.

This type of clutch is available in the form of a shaft coupling or as a pulley clutch. In the latter case, it is provided with a longer extension on the drum end to accommodate a pulley.

## Carl G. Barth Honored by Taylor Society

CARL G. BARTH, who was a pioneer in the machine building industry, and to whom many other industries owe modern principles of production and management, has been elected an honorary member of the Taylor Society. Only two other men have been thus honored by the Society, which is the national organization for the promotion of science in management, these being Frederick W. Taylor himself and Henri Le Chatelier, the prominent engineer who developed scientific management in France.

Mr. Barth, after engineering studies in his native land, Norway, came to this country in 1881 and was employed as a draftsman by William Sellers & Co., where he remained for 14 yr., with the exception of 1 yr. From 1895 to 1899, he was engaged in designing and engineering work in St. Louis in technical mathematics and manual training and in preparing engineering text books. Then he became associated with Mr. Taylor at Bethlehem, with whom he worked on the historic foundations of scientific management. Under Mr. Taylor's guidance, he conducted experimental work on metal cutting tools and applications of slide rules in the plants of the Link-Belt Co. and the Tabor Manufacturing Co.

Mr. Barth's work on the fundamental formulas in cutting metals has received world-wide recognition as one of the most important contributions to machine development.

U. S. CIVIL SERVICE COMMISSION announces an examination, June 22, for both men and women, for specialist in natural gas conservation, to fill a vacancy in the Bureau of Mines for duty in the field, at $2160 to $2500 a year, and vacancies in positions requiring similar qualifications, at these or higher or lower salaries. Appointees whose services are satisfactory may be allowed the temporary increase granted by Congress of $20 a month. For the present vacancy female eligibles are desired. Competitors will be rated on education and experience, and publication, reports, or essays. Applicants must have graduated from a college or university of recognized standing, and, in addition, must have had at least six months' actual experience in lecturing on and demonstrating before audiences the efficient use of natural gas and gas-burning appliances. Additional credit will be given for special study in home economics work. Apply for Form 2118, stating the title of the examination desired, to the Civil Service Commission, Washington, D. C.

# News Notes

PRACTICALLY EVERY type of machine used in handling freight shipments at the steamship piers and railroad terminals will be exhibited at the Electrical Exposition, to be held at the Grand Central Palace, New York, in October. These exhibits, which are to be a special feature of the show, will be presented and demonstrated under the auspices of the Material Handling Machinery Manufacturers' Association. In order to have sufficient room to demonstrate properly small trucks, portable cranes, trailers, and so forth, the whole third floor will be given over to this purpose. This will be the first time that the Electrical Show has specialized to any degree in one particular branch of electrical machinery. Economic conditions in the country, though gradually improving, are still far from their pre-war standards, and it is, in a measure, to help better these conditions through the more general use of electrical industrial machinery that this new policy of the Electrical Show Co. has been adopted. Hotel, home, and office appliances are to retain the same prominent positions they have always held at the show and they will be featured in the same manner this year as in previous years. The advent of larger machinery will in no way curtail their prominence.

TO MEET the needs of a larger attendance of post-graduate students—mainly from foreign countries and from states outside of Colorado—the management of the Colorado School of Mines (international), located at Golden, Colo., 17 mi. west of Denver, has decided to so enlarge the curriculum as to provide for seven lines of study after the sophomore year, to be known as metal mining, metallurgy, mining geology, civil engineering, chemical engineering, mechanical engineering and electrical engineering.

The degrees representing these courses will be engineer of mines (E.M.), metallurgical engineer, civil engineer, chemical engineer, mechanical engineer (M.E.), and electrical engineer (E.E.).

The faculty will be strengthened to meet the enlarged program.—Denver "Rocky Mountain News."

WESTINGHOUSE, CHURCH, KERR & Co., Inc., announce the removal of their offices from 37 Wall St. to 125 E. 46th St. (Grand Central Palace). Until the completion of the merger with Dwight P. Robinson & Co., Inc., of which due announcement will be made, the business will be conducted under the present name.

THE NEW FACTORY of the Chicago Fuse Mfg. Co., recently acquired from the Otis Elevator Co., is a building the total floor space of which is 125,000 sq. ft., with a frontage of 140 ft. on Laflin St. and 360 ft. on Fifteenth St., Chicago. It is a modern, daylight, two-story factory structure, with a four-story office section, protected throughout with sprinkler system, and is situated right on the switch tracks of the B. & O. C. T. Co. It is said to be the largest factory in this country engaged exclusively in the manufacture of fuses and switch boxes. The building has been entirely remodeled, in accordance with the most approved ideas of industrial engineering practice, and the most modern equipment installed. In addition to providing larger and more modern manufacturing facilities, the new plant will permit unusual efficiency in marketing the company's products. With the additions completed, the buildings and equipment will represent an investment of more than a half million dollars.

ON MAY 12, the Emperor of Japan decorated, with the Order of the Rising Sun, E. M. Herr, of Pittsburgh, president of the Westinghouse Electric & Manufacturing Co., and L. A. Osborne, of New York, president of the Westinghouse Electrical International Co. These American manufacturers have been several months in Japan, studying Oriental industrial conditions. The company which they represent has always had close relations with Japan and has supplied that country with a great deal of power machinery. It has also undertaken the training of a number of Japanese students at its works. The Order of the Rising Sun is the highest honor the Emperor can bestow. Mr. Herr received the third class and Mr. Osborne the fourth, the higher classes being awarded only to Japanese national heroes.

U. S. CIVIL SERVICE COMMISSION announces an examination, June 22, for both men and women, for safety engineer, to fill a vacancy at the Amatol Arsenal, Hammonton, N. J., at $2500 to $3000 a year and vacancies in positions requiring similar qualifications, at these or higher or lower salaries. For the present vacancy male eligibles are desired. Competitors will be rated on physical ability, training and experience. Apply for Form 1312.

U. S. CIVIL SERVICE COMMISSION announces an examination, June 23, for both men and women, for mining draftsman, to fill a vacancy in the Bureau of Mines, Pittsburgh, Pa., at $1200 a year, and future vacancies requiring similar qualifications throughout the United States, at this or higher or lower salaries. Appointees whose services are satisfactory may be allowed the temporary increase granted by Congress of $20 a month. Competitors will be examined in drawing (preparation of inked drawing suitable for a mine report showing ventilation, haulage, or other details relating to surface or underground layout), training and experience. Apply for Form 1312.

# Book Reviews

ARMATURE WINDING AND MOTOR REPAIR, by Daniel H. Braymer; 499 pages; 301 illustrations; first edition, New York, 1919.

Except for the comparatively small amount of material appearing from time to time in the various trade and technical periodicals, but little information has heretofore been available on the subject of armature winding and general motor repair work, especially such as is of a genuinely practical nature. It is therefore obvious that a book devoted to this subject should prove of real value to the repair man.

As the author states, no attempt has been made to discuss the subject of armature winding from theoretical or design standpoints. On the contrary, it is a compilation of practical methods used by repairmen and

winders and presented in such a manner as to make it readily understandable and comprehensive. The text is augmented by many clear-cut illustrations, which further enhance the value of the book.

The first two chapters are devoted to a thorough discussion of both direct- and alternating-current armature windings, while Chapter III explains in detail the various methods employed in repair shops for the rewinding of direct-current armatures. Following this are taken up such subjects as the making of commutator connections, the testing of direct-current windings, coil insulation, methods for the rewinding of alternating-current machines, commutator repairs, brush adjustments, machine troubles and their solutions, etc. Chapter XVII explains in detail repair shop equipment and tools.

The appendix, appearing on the last 35 pages, contains many tables, formulas and wiring diagrams of value to the practical electrical worker.

ELEMENTS OF STEAM AND GAS POWER ENGINEERING, by Andrey A. Potter and James P. Calderwood; cloth; 300 pages; 225 illustrations; first edition; New York, 1920.

With the short space at their disposal, in which to cover a broad field, the authors of this book have done well. Although the material used has had to be condensed, and the number of examples of commercial apparatus reduced to a minimum, the text and illustrations present clearly the various subjects treated.

This book was prepared primarily as a text book for students in engineering schools, in order to familiarize them with power plant equipment, before they take up the more abstract study of thermodynamics. The method of handling the material presented, gives to the book a certain value to the power plant operator.

The contents are divided into three parts; the first being devoted to steam, the second to gas power, and the last to the application of steam and gas power to various classes of machines, such as locomotives, automobiles, etc. Each chapter is so arranged as to give the fundamental principles, structural details, auxiliary parts, and operation and management of the equipment under consideration, in the order named.

The opening chapter covers the fundamentals of power engineering. Then follow nine chapters on steam power, and four on gas power. The last two chapters treat of steam and gas power as applied to special types of machinery, such as locomotives, automobiles, tractors, etc.

## Trade News

WORTHINGTON PUMP & MACHINERY CORPORATION, 115 Broadway, New York, announces that, in addition to its lines of hydraulic machinery, manufactured since 1840, it has completed preparations to furnish improved water power machinery of all capacities for low, medium and high head service, including oil pressure systems, water wheel governors, and other auxiliaries. The company is entering the field equipped to produce hydraulic turbines to meet the highest standards in design, efficiency and workmanship, to supplement its experienced staff, familiar with hydraulic problems, with the services of competent designers having many years of successful experience. Its hydraulic turbine department is prepared to receive inquiries, which will be given prompt and careful attention.

ENGINEERING clubs and societies, manufacturers' associations, commercial organizations, technical schools, and the educational departments of large corporations will be interested in the announcement that the Diamond Power Specialty Co., Detroit, Mich., now has available for free distribution three copies of its motion picture, "Coal Is King." This picture was prepared from a scenario by Robert June, and the pictures were taken under his direction by the Ford Motor Co.

The film was originally prepared as part of the coal conservation campaign used during the war, but has just been completely revised and brought up to date, all war material being eliminated and much new material added. The film deals with good and bad methods of coal mining and transportation, good and bad methods of firing, combustion losses and their minimization, power plant instruments, such as draft gages, $CO_2$ recorders and their uses, losses caused by leaky boiler settings, good and bad management of the boiler room, and the necessity for keeping the boiler surfaces clean is properly brought out. Pictures of scale and soot removal, losses caused by cutting in stand-by boilers too early or too late, losses caused by uncovered steam pipes, leaky pipes, steam traps, etc., are shown.

The film is in four reels, requiring approximately 50 min. to be shown. Bookings are now being made for the summer and fall, and those interested should make their reservations without delay, in order that schedules may be completed.

THE SANDUSKY PACKLESS VALVE CO. has recently made arrangements with the Advance Engineering Co., of New York City, to handle Sandusky valves in the New York district.

MERCANTILE and Industrial Buildings of Concrete, a new illustrated booklet published by Portland Cement Association, 111 W. Washington St., Chicago, discusses the merits of concrete buildings with reference to cost, speed of construction, resistance to fire, adaptability, efficiency of operation, maintenance, depreciation and obsolescence.

BRIDGEPORT BRASS CO. recently prepared a book on brass, commemorating the introduction of electric brass-melting into commercial practice. The book describes and illustrates in detail the art of brass making, dating back hundreds of years, and leading up to the most modern practices now in use, including the electric casting shop. The important steps in the making of tubes, sheet, rods and wire are also shown. Following the description of the plant, are discussed the properties of brass as affected by composition, cold-working and heat treatment, with the idea of assisting engineers in drawing specifications. In the compilation of this work the authors deviated from life-long conventions and traditions of the brass industry by making an open book of the practices and processes of brass making.